POWER

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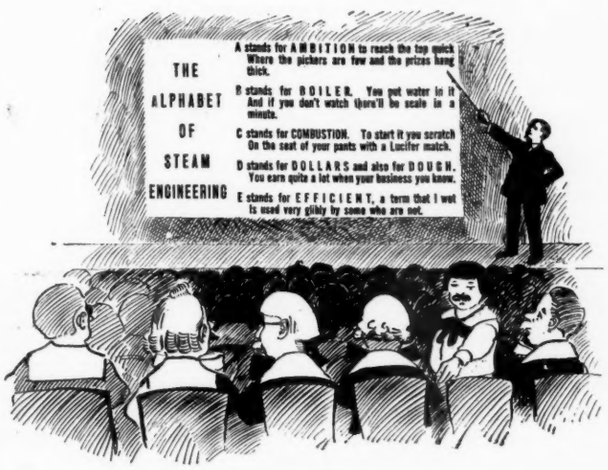
The Alphabet of Steam Engineering

By JOS. W. HAYS

A stands for **AMBITION**
to reach the top quick,
Where the pickers are
few and the prizes
hang thick.

B stands for **BOILER.** You
put water in it
And if you don't watch
there'll be scale in a
minute.

C stands for **COMBUS-**
TION. To start it you
scratch
On the seat of your pants with a Lucifer match.


THE
ALPHABET
OF
STEAM
ENGINEERING
A stands for AMBITION to reach the top quick Where the pickers are few and the prizes hang thick.
B stands for BOILER. You put water in it And if you don't watch there'll be scale in a minute.
C stands for COMBUSTION. To start it you scratch On the seat of your pants with a Lucifer match.
D stands for DOLLARS and also for DOUGH. You earn quite a lot when your business you know.
E stands for EFFICIENT, a term that I wot Is used very glibly by some who are not.

D stands for **DOLLARS** and also for **DOUGH.**
You earn quite a lot when your business you know.

E stands for **EFFICIENT,** a term that I wot
Is used very glibly by some who are not.

F stands for **FURNACE** and **FIREMAN,** too;
When they both tend to business the coal man looks
blue.

G stands for **GASES** that go up the flue.
Look out or you'll waste a heat unit or two.

H stands for the **HOLES** that let air through the fire.
You must watch for such air holes; with waste
they conspire.

I stands for **INTENTION** to stop up the leaks;
You can do it today. Why defer it for weeks?

J stands for the **JOY** that the manager fills.
When the month's balance sheet shows some small
fuel bills.

K stands for the **KNOWLEDGE** that some engineers
Acquire quite quickly while others take years.

L stands for the **LIGHTS** that in dark corners gleam
When the chief engineer knows the cost of the steam.

M stands for the **MOMENT** to stop fuel waste;
The moment is Now and the password is Haste.

N stands for the **NOTION**
at one time supreme
That the plant was all
right when it made
enough steam.

O stands for **OXYGEN;**
wide is its use.
"Oxy" means "acid"
and "gen" means "pro-
duce."

P stands for **POWER.** It
comes from a press,
And sometimes from a
Corliss or turbine, I guess.

Q stands for the thing that they call **QUESTIONNAIRE.**
You fill out the blanks and you put up a prayer.

R stands for **REPAIRS** which you ought in all reason
Get out of the way in the slack summer season.

S stands for the **STEAM** you waste coal to produce
And you waste the same steam when you put it
to use.

T stands for **TURBINE.** Our friend Jamie Watt
Would gasp could he see us shoot steam through a
pot.

U stands for **UPTAKE.** For a sample of gas
For your Orsat, avoid it and use the last pass.

V stands for the thing that we often call **VIM.**
Without it you sink. When you have it you swim.

W stands for **WATER.** In one more short year
We'll all have to drink it and play it is beer.

X stands for **XPERT** and **XPERIENCE** too.
When you've gathered the second the first becomes
you.

Y stands for the jaw-breaker **YOUGHIOGHENY,**
A coal and a town out in West Pennsylvany.

Z stands for **ZEST** for the work we are in
And with Zest comes Success. **NOW LET'S GO**
IN AND WIN!

Bureau of Mines' New Laboratories

An unusually well-illustrated article describing the new laboratories of the Bureau of Mines, and telling of the plans of the Fuel Section of the Bureau.

IT MAKES one feel good to get new tools with which to work. So there will be rejoicing in the fuel-mining and fuel-using industries to know that Uncle Sam has just completed for them a workshop, the finest of its kind to be found anywhere. And this workshop, with its corps of engineers and chemists, reaches out to the most remote power plant, oil well and refinery, to the farthest mine and to the most isolated coal and oil consumer.

Almost everyone knows Carnegie "Tech" and its imposing location atop the hills that look down into the valleys from which rises the smoke of the great mills that have made Pittsburgh an industrial colossus. The new laboratories of the Bureau adjoin "Tech," fronting on Forbes Street some several hundred feet up from the Carnegie Museum, forming a part of that famous civic center in which are located the University of Pittsburgh, Mellon Institute of Industrial Research, the Athletic Club, Masonic Temple and other beautiful structures. While the material and architecture of the laboratories were made to harmonize with "Tech," the buildings, as well as their layout, remind one of the Wentworth Institute, Boston.

The buildings are laid U-shape, the administration building connecting two wings, the right mechanical, the left chemical. The outside, over-all dimensions are: Total front on Forbes Street, 332 ft.; total depth each wing, 211 ft.; width each wing, 46 ft. The mechanical laboratory is 46 x 211 ft. The fuel laboratory is 51 x 65 ft. with 26-in. ceiling. Back of and with their roofs on a level with ground floor of the laboratories, are the power plant and the fuel-testing laboratory, where Henry Kreisinger and his associates will conduct their experiments, in which *Power* readers are so vitally interested. This fuel-testing laboratory is of concrete construction, like the power plant, and is large enough to accommodate much apparatus. The walls are about 70 per cent. glass, giving excellent light conditions. Later, as the work of the laboratories increases, the fuel wing will extend out over railroad tracks already laid, and eventually the buildings will bridge the great ravine that now separates the laboratories from the Carnegie Institute of Technology.

The first floor of the chemical wing is occupied by the petroleum laboratory and the coal-sampling plant. In the latter samples of coal are prepared for analyses, and from 300 to 400 such analyses are made per month. The coal sample, as it comes from the mine or the car, is crushed to 10-mesh in a roller mill, then air-dried, after which it is ground to 60-mesh in a ball mill; most of this 60-mesh sample will pass through a 100-mesh screen. The coal is now ready to be sent upstairs for analysis, the containers being 4-oz. bottles, each carrying 40 grams of the coal. All analyses are recorded on cards which are kept on file by the Service Department of the Laboratories. For making coal analyses a calorimeter of the Parr type, modified and designed by the Bureau, is used. The coal sample coming in for analysis bears a number which is in one column of an indicating board, the other columns each representing one of the subjects for determination; that is, moisture, sulphur, ash, volatile, fixed carbon and heating value. A fresh sample to be analyzed has its number, and in each of the columns mentioned a brass brad is stuck; this is removed when the determination which it represents is made. A glance at the board therefore indicates the progress of the analysis.

Of course the Bureau uses a great variety of instruments, gages, etc., some of which are special and de-

signed and made by the Bureau. To do this work there is a corps of instrument makers, and a well-fitted machine shop for them is maintained. The shop is shown on page 386. Instruments, gages, meters, thermometers, etc., used by the Bureau are calibrated in a room fitted for the purpose and located on the second floor.

Now all gas-analysis work is under one head and is done in one room exceptionally well fitted for the work. Mine-gas samples are collected in thin glass bottles, evacuated of air and sealed. To collect a sample one locates the bottle where one wishes, breaks off the small glass tip, allowing the gas to rush into the air-evacuated bottle. When the sample is collected, the opening is sealed with wax. Samples of flue and other gases are drawn over mercury. Men from this laboratory are trained to make as high as forty flue-gas analyses an hour.

The Mining Division, with its special laboratories, its rescue work apparatus, etc., is especially interesting, but space permits description only of that which concerns the power-plant man.

During the war, owing to urgent war work, many of the rooms were used for purposes other than originally intended. This has caused some laboratories to temporarily occupy other rooms.

The laboratory where investigations in combustion of fuels and in steam-boiler performance are to be made has not been fully fitted up as yet owing to the press of urgent war work upon Mr. Kreisinger, the engineer conducting such researches. But *Power* readers, and all industrial consumers of fuel, in fact, will be pleased to know that a praiseworthy program upon which work will soon begin, has been laid out for this laboratory.

This department has thoroughly treated of hand-firing and low rate combustion, particularly in horizontal-tubular boilers. One of the first items on the new program will be investigations into combustion on underfeed multiple-retort stokers. Power-plant men will look with interest for the results of this work, despite the fact that considerable study has already been given the subject by public-service corporations, stoker manufacturers and individual engineers.

The Bureau will soon begin studies in connection with the present use of powdered coal for power plants and metallurgical purposes. Of course powdered coal for boiler furnaces is not new, but it is true that nearly all those conducting tests and publishing results have been enthusiasts. The Bureau will have the advantage of beginning its work without prejudices or preconceived opinions.

Further studies are to be made of heat transmission in boilers. The metallurgical industry, particularly, is interested in the combustion of various cokes, and this will be investigated. Design of furnaces for house-heating boilers is another item on the program. The foregoing work will be done for the most part in the fuel-testing laboratory.

Of importance is the subject of the partial distillation of bituminous coal, taking out the volatile for the valuable hydrocarbon products, using the residue for fuel. This process leaves the coal or residue with about 75 per cent. of its original heating value. The new laboratories likely will be the scene of investigations in this highly portentous field. The Bureau also will at its earliest convenience attempt determinations of the specific heat of the various gases in flue gas. There follow the plans of the Fuel Section of the Bureau:

Outline of Work in Fuel Section

Steam Boilers and Furnaces

Field Work:

1. Coöperation with Emergency Fleet Corporation; baffling of marine boilers; design of marine boiler furnaces and study of combustion in same. Study of insulating materials used in furnace walls.
2. Study of lignites as fuel for steaming purposes.
3. Storage of coal.

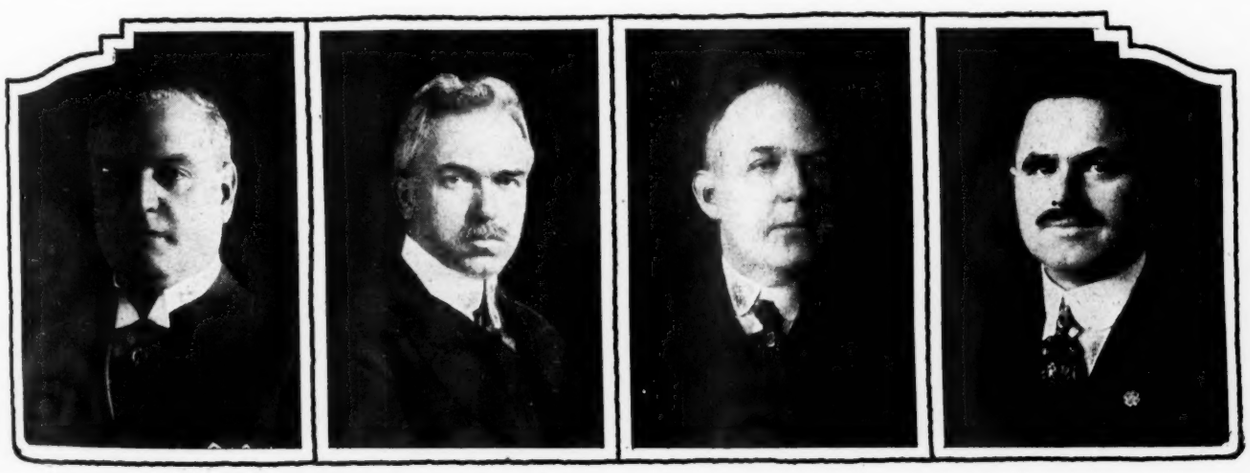
Laboratory Work:

1. Study of the draft required for burning at various rates, different kinds of coal and different mixtures of sizes.
2. Study of the effect of melting point and the composition of ashes on the clinker trouble in boiler furnaces.
3. Study of the use of lignites for house heating.
4. Study of the combustibility of carbon in different forms—coke, soot, anthracite, etc.
5. Study of heat transmission in steam boilers.
6. Effect of scales on the heat transmission in steam boilers.

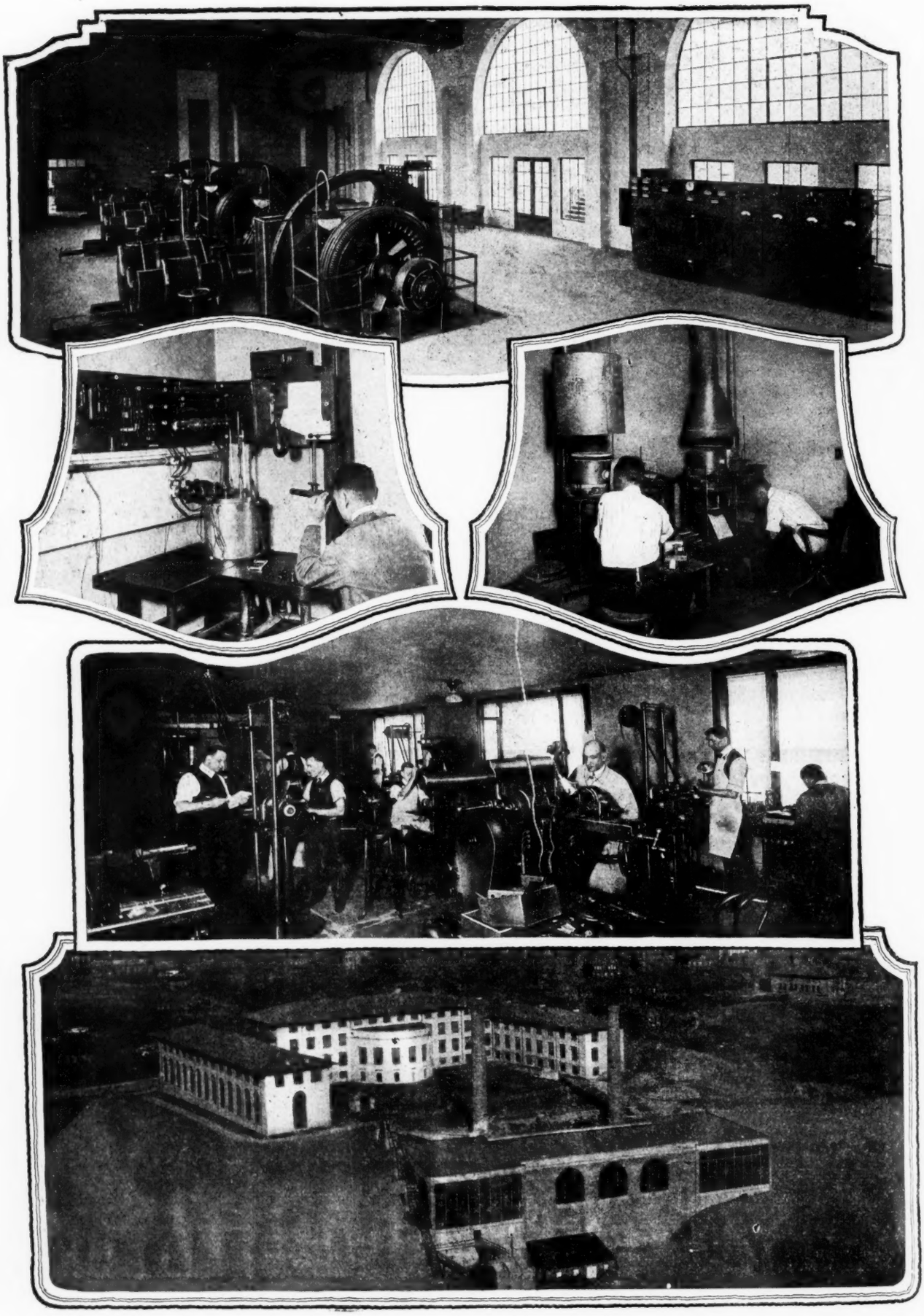
Powdered Coal

Field Work:

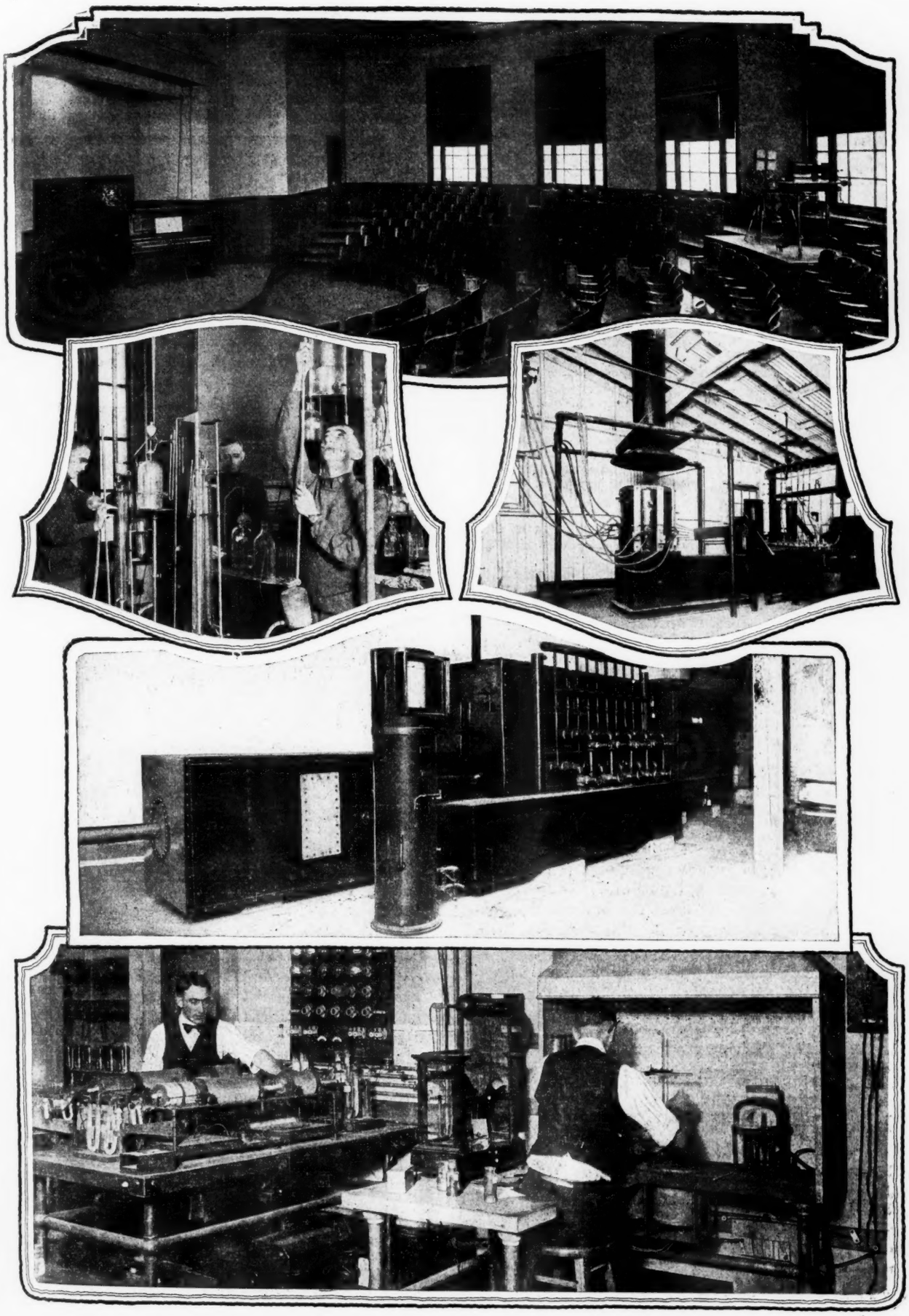
1. General survey of the use of powdered coal for steam and industrial purposes.
2. Coöperation with some firm to help develop the use of powdered coal for steam and other purposes.
3. Investigation of the durability of furnace lining in powdered-coal furnaces.
4. Storage of powdered coal.



FROM LEFT TO RIGHT: VAN H. MANNING, O. P. HOOD, DORSEY A. LYON, HENRY KREISINGER



ENGINE ROOM, COAL CALORIMETER TESTING, ASH-FUSION TESTS, MACHINE SHOP, REAR VIEW OF LABORATORIES



AUDITORIUM, GAS ANALYSIS, FUEL-TESTING FURNACE, DRYING OVENS, VIEW IN COAL-TESTING LABORATORY

Laboratory Work:

1. Study of the composition and the fusibility of ash as affecting the removal of ash from industrial and boiler furnaces.
2. Study of suitable refractory material for lining furnaces, to resist the slagging action of ash from different coals.

FUEL IN METALLURGICAL FURNACES

Field Work:

1. Study of the design and economic operation of metallurgical furnaces.
2. Study of probable application of mechanical stokers to metallurgical furnaces.

Laboratory Work:

1. Study of the combustibility of different cokes in contact with oxygen and CO_2. (This work to be done in coöperation with the Metallurgical Section.)

BYPRODUCT PLANT

Field Work:

1. General survey of the byproduct-plant industry and of the possible lines of development in near future.
2. Coöperation with some industrial plant in solving certain phases of the byproduct industry on commercial scale.

Laboratory Work:

1. Examination of tars and oils, and developing new methods for determining the actual compounds, the action of these under heat treatment, and the conditions favorable and unfavorable for their production. Study of possible new products and new uses.
2. Study of relative value of coke for blast furnaces and other uses. This is the same problem as mentioned in "Fuel in Metallurgical Furnaces, Laboratory Work (1)."
3. Study of expanding property of coal during coking.
4. Study of coals of the country with relation to coking properties.

USE OF FUEL IN CERAMIC INDUSTRY

1. Fuel economy and to produce better product.

On the second floor of the administration building are the offices of the mechanical engineers. It is here that data from tests and researches are worked up into form for publication in the bulletins of the Bureau.

The top floor of the administration building is given over to the technical-service department of the Bureau. Here photographs, drawings, prints, filing of important data, etc., are done for the various laboratories. It is as well fitted a place as the writer has seen in his many travels.

Among the many views of the laboratories and apparatus given in this article, is one of the engine room, showing the Nordberg engines. The boiler room, containing two 500-hp. Babcock & Wilcox boilers with Playford stokers, is temporary. Later, as the laboratories grow, it will be permanently located back of and parallel with the engine room.

Acknowledgment is due to Dorsey A. Lyon, supervisor of stations, Henry Kreisinger, engineer, and R. A. Wood, in charge of the service department, for their coöperation in the preparation of this article.

Blackburn-Smith Inclosed Tank Switch

The human element is not always dependable as is well known, and this is especially true in regard to controlling pumps used for filling roof tanks, etc., which are frequently forgotten, with the consequence that the tank overflows before the attendant remembers to shut down the pump.

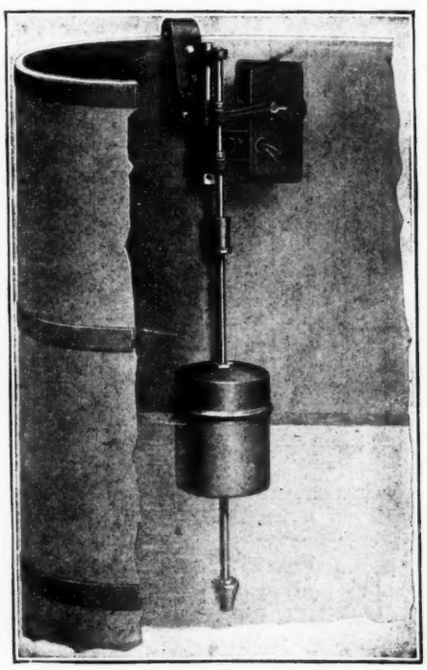
Various kinds of automatic switches have been devised for controlling the starting and stopping of motor-driven tank pumps, among them being the Blackburn-Smith inclosed tank switch, made by the Blackburn-Smith Corp., 105 West 40th St., New York City.

This switch is of the single-pole double-break type, is instantaneous in action and is suitable for use with tanks, etc., wherever regulation of liquid level between high and low limits is required. This regulation is obtained by a float operating the switch, which in turn actuates a solenoid controlling mechanical or other electrical devices.

The joint of the case is flanged to permit the use of a gasket when desired for waterproofing, and the internal electrical and mechanical parts are separated by an inside dividing partition which forms two separate compartments.

The fixed contacts are short cylinders of carbon, the moving contact is a folded copper strip and a flat spring keeps the contact piece always in correct position.

The operation is as follows: As the float riding up and down on a guide rod hits a limiting stop on the rod,



INCLOSED TANK SWITCH

the rod is carried up or down, and through collars upon its upper end imparts a corresponding movement to the switch lever. The movement of the lever oscillates a shaft and "grasshopper" levers, which in turn move a roller across a cam on the end of the electrical-contact lever. The roller is held closely to the cam by a coil spring fastened to the dividing partition in the case. The tension from this spring throws the contact lever with a quick positive motion the instant the roller passes over the center of the cam. This switch is furnished alone or with auxiliaries for mounting either on the cover of or to the wall of a tank.

Advantage should be taken so far as possible of low-load periods to reduce the peak-load difficulties of the plant. For instance, boilers should be blown at noon hour or other times of light load, and this is the time to fill water tanks, charge storage batteries, blow tubes, run ash and coal conveyors, etc.

Refrigeration-Plant Log Sheets

The Committee on Uniform Log Sheets of the National Association of Practical Refrigerating Engineers has drawn up the forms shown. Above: Daily Report Sheet. Below: Monthly Report Sheet

Plant _____ Date _____ 19 ____

TIME	STEAM PRESSURE	CONDENSER PRESSURE (MACHINE No. 1 2 3)	TEMPERATURE OF DISCHARGE GAS (MACHINE No. 1 2 3)	RETURN PRESSURE (MACHINE No. 1 2 3)	TEMPERATURE RETURN VAPOR (MACHINE No. 1 2 3)	R. P. M (MACHINE No. 1 2 3)	WATER TEMPERATURE: TO HEATER	TO BOILER	TO COOLING TOWER	FROM COOLING TOWER	TO CONDENSER	FROM CONDENSER	SUPPLY	FROM ABSORBER	FROM RECTIFIER	TO PRECOOLER	TO CANS	BRINE TEMP. TO STORAGE	FROM STORAGE	TEMPERATURE FREEZING TANK (TANK No. 1 2 3)	TEMPERATURE ROOMS (ROOM No. 1 2 3 4 5 6)	TEMPERATURE ICE STORAGE	VACUUM GAGE	DRAFT GAGE	OUTSIDE TEMPERATURE	FUEL USED	CO_2
7 A.M.																										
10 A.M.																										
1 P.M.																										
4 P.M.																										
7 P.M.																										
10 P.M.																										
1 A.M																										
4 A.M.																										
A.V.																										

MACHINE NO	START	STOP	START	STOP	TOTAL
1					
2					
3					

TOTAL No. BLOCKS PULLED, DAY
" " " " NIGHT
" " " IN ICE HOUSE
" " " IN DUMP ROOM
TOTAL TONS PULLED
TOTAL TONS ON HAND, 7 A.M.
QUALITY OF ICE

METER READINGS 7 A.M.
OIL
GAS
WATT
WATER
BRINE
TONS OF COAL USED
CARS SHIPPED

ENGINEERS
FIREMEN
TANKMAN
VAULTMEN
EXTRA LABOR
CHIEF ENGINEER

MATERIAL RECEIVED

MATERIAL USED

REMARKS (SHUT DOWNS, ACCIDENTS ETC)

Signed _____

Plan. _____ Month _____ 19 ____

DATE OF MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total	Average
HRS. OPERATED, MACHINE No. 1																																	
R.P.M.																																	
RETURN TEMPERATURE																																	
DISCHARGE "																																	
HRS. OPERATED MACHINE No. 2																																	
R.P.M.																																	
RETURN TEMPERATURE																																	
DISCHARGE "																																	
HRS. OPERATED MACHINE No. 3																																	
R.P.M.																																	
RETURN TEMPERATURE																																	
DISCHARGE																																	
STEAM PRESSURE																																	
RETURN "																																	
DISCHARGE "																																	
VACUUM																																	
DRAFT																																	
OUTSIDE TEMPERATURE																																	
TEMPERATURE, TANK No. 1																																	
" " " 2																																	
" " " 3																																	
" LIQUID TO TANKS																																	
" SUPPLY WATER																																	
" " TO TOWER																																	
" " FROM																																	
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" DIS. " TO PRECOOLER																																	
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" FEED WATER																																	
" FLUE GAS																																	
" ICE STORAGE No. 1																																	
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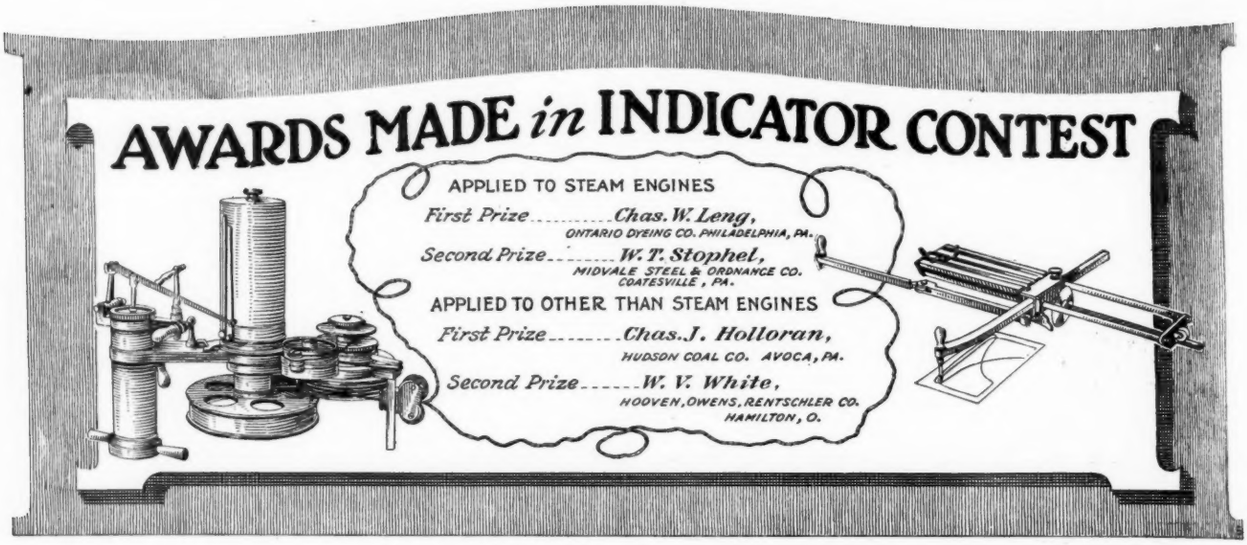
TOTAL No. OF BLOCKS PULLED TANK No. 1																																	
" " " " No. 2																																	
" " " " No. 3																																	
"																																	
" " ON HAND 7 A.M.																																	
TONS OF COAL USED																																	
FUEL OIL OR GAS METER READING																																	
WATT METER READING																																	
WATER SUPPLY METER READING																																	
BRINE																																	
TEMP. BRINE TO STORAGE																																	
" " FROM																																	

REMARKS

MATERIAL	RECEIVED	USED	ON HAND

No. OF MEN EMPLOYED MFG.	EXTRA LABOR	KIND OF WORK
ENGINEERS		
FIREMEN		
OILERS		
TANKMAN		
VAULTMAN		

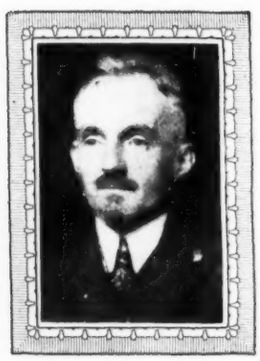
Signed _____


AWARDS MADE in INDICATOR CONTEST
APPLIED TO STEAM ENGINES
First Prize..... Chas. W. Leng,
ONTARIO DYEING CO. PHILADELPHIA, PA.
Second Prize..... W. T. Stophel,
MIDVALE STEEL & ORDNANCE CO. COATESVILLE, PA.
APPLIED TO OTHER THAN STEAM ENGINES
First Prize..... Chas. J. Holloran,
HUDSON COAL CO. AVOCA, PA.
Second Prize..... W. V. White,
HOOVEN, OWENS, RENTSCHLER CO. HAMILTON, O.

WITH a view to stimulating interest in effecting economies through proper valve settings of engines and other reciprocating apparatus, the Trill Indicator Co. some months ago offered through *Power* to award an indicator to the one reporting the most meritorious use of such instrument on a steam engine and another to the best report of its use on other than a steam engine. Second prizes consisting of planimeters were offered in each case.

At the time, in announcing the contest, it will be recalled that *Power* secured the consent of three prominent engineers to act as judges. These were Charles T. Main, then president of the American Society of Mechanical Engineers; David Moffat Myers, advisory engineer to the United States Fuel Administration; and George H. Barrus, then chairman of the Power Test Committee of the American Society of Mechanical Engineers.

The contest closed on Nov. 30, 1918. After going through the numerous papers submitted, the judges have arrived at an almost unanimous decision, which is as announced above. The four successful papers are reproduced herewith.

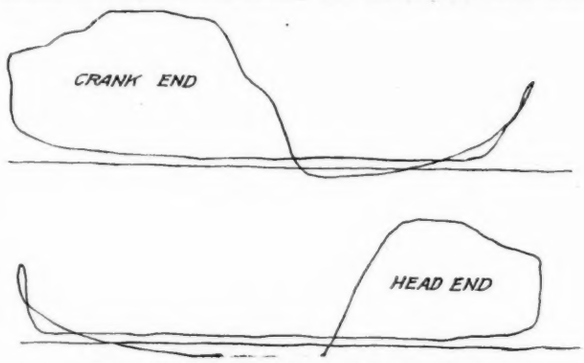


CHARLES W. LENG

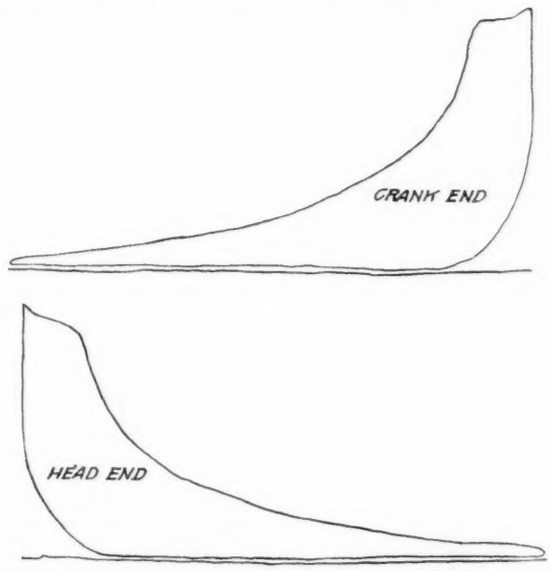
THE four diagrams were taken from a 9 x 14-in. Salem Buckeye engine at the Harrison Bros., Gray's Ferry Chemical Works, Philadelphia, Nov. 7 and 9, 1893, at which time the writer was employed at this plant as assistant engineer. The engine mentioned, known as No. 38 electric light engine, was one of fifty-four engines of various types and sizes ranging from 20 x 42-in. Green to small Westinghouse Juniors, which accounts for the fact that it ran in the condition shown in the first two diagrams without its extravagance being noticed, it being only a small portion of the total load.

Among the first duties assigned the writer was the indicating of the various engines, which resulted in the production of the most valuable curios in his collection.

This is the only case that has come to the notice of the writer in which regulation was effected by varying the point of admission instead of cutoff, and while the actual saving by correcting the defective valve action was only a small percentage of the total plant load, the relative loss is a ridiculously large amount.



BEFORE CHANGING POINT OF ADMISSION



AFTER CHANGING POINT OF ADMISSION

Investigation brought out the information that the engine had, prior to its application to the lighting load, been run in the opposite direction and when reversed,

the main eccentric only was adjusted for the new direction without reversing the governor action.

In a plant in which this was the only engine used, this condition would probably have been discovered without the indicator, but the fact that the engine ran smoothly and with acceptable regulation on a lighting load for a considerable period, would indicate that this condition might have prevailed indefinitely had it not been for the application of the indicator.

Philadelphia, Penn. CHARLES W. LENG.

W. T. STOPHEL

THERE are submitted herewith indicator diagrams taken from a 12 x 18-in. engine driving a Mesta plate and scrap shear. The engine is of piston-valve type. The diagram marked "as found" shows the very poor setting of the valves. With this setting it was difficult to start the engine at all, and at times the flywheel would have to be turned by hand and the steam then turned on before the engine would start. Besides the valve being far out of position, there was, and is still, considerable lost motion in the valve rod.

The card marked "final" shows a marked improvement over the original setting. The results as calculated from the cards are as follows:

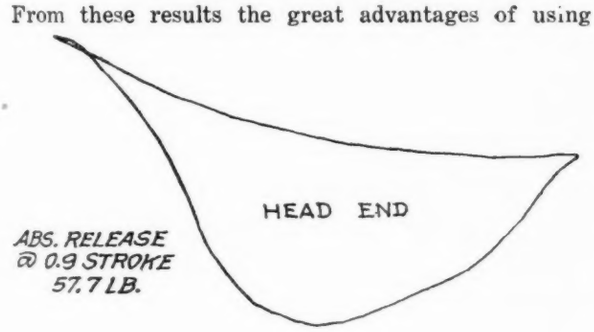
"AS FOUND"

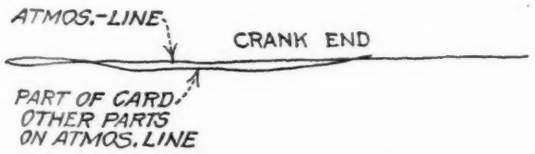
Horsepower	=	6.9
Steam per hp.-hr.	=	93.2 lb. (dry)
Steam per hp.hr.	=	121.2 lb. (wet)
Total per hour	=	836.0 lb. (wet)

"FINAL"

Horsepower	=	16.3
Steam per hp.-hr.	=	45.7 lb. (dry)
Steam. per hp.-hr.	=	59.4 lb. (wet)
Total per hour	=	968.0 lb. (wet)

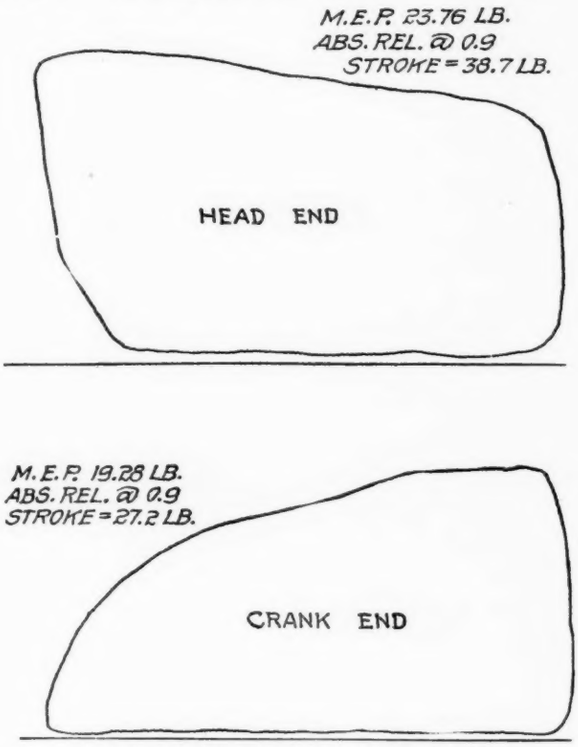
From these results the great advantages of using





DIAGRAMS SHOWING VALVE SETTING "AS FOUND"

an indicator can easily be seen, as in this case the water rate is lowered 51 per cent. and they are now able to start the shear without any trouble and are also getting much more power to do the work required.



DIAGRAMS SHOWING "FINAL" SETTING

The diagrams were taken with a Trill continuous-type indicator. W. T. STOPHEL.

Coatesville, Penn.

CHAS. J. HOLLORAN

THE attached diagrams were taken from a 16 and 25 x 25 and 16 x 24-in. cross-compound two-stage steam-driven air compressor. Diagram No. 1 was taken from the 25-in. intake cylinder and shows an m.e.p. of 22 lb. as traced by indicator. The dotted lines show the plotted adiabatic curve, the crank end showing an m.e.p. of 19.75 lb., and the head end 19 pounds. Diagram No. 2 was taken from the same cylinder after renewing the poppet discharge valves, on both head and crank ends. The crank-end m.e.p. was 18 lb. and the head-end 19 lb.

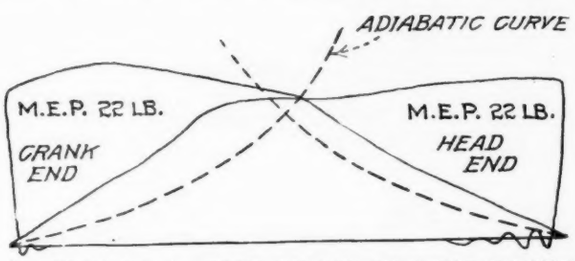


DIAGRAM NO. 1. FROM INTAKE CYLINDER BEFORE RENEWING POPPETS

Diagram No. 3 was taken from the high-pressure or second-stage cylinder. The head end shows an m.e.p.

of 89 lb. as traced by the indicator. After plotting the adiabatic curve, the same end shows an m.e.p. of 66 lb. The crank end as traced by indicator shows an m.e.p. of 67 lb. No. 4 was taken from the same cylinder after renewing the poppet valves with the result that the crank-end m.e.p. was 57 lb. and the head-end 58 pounds.

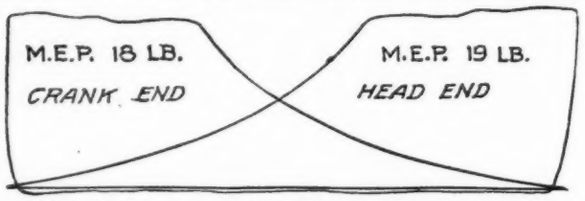


DIAGRAM NO. 2. FROM INTAKE CYLINDER AFTER RENEWING POPPETS

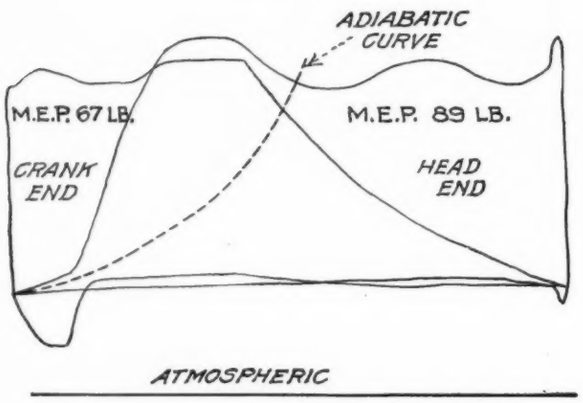


DIAGRAM NO. 3. FROM HIGH-PRESSURE CYLINDER BEFORE RENEWING POPPETS

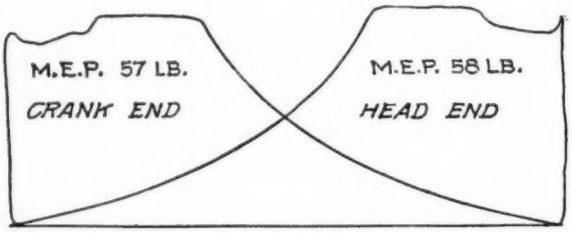


DIAGRAM NO. 4. FROM HIGH-PRESSURE CYLINDER AFTER RENEWING POPPETS

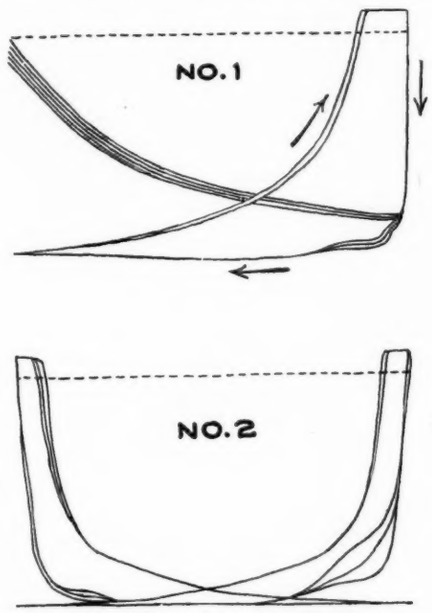
CHARLES J. HOLLORAN.

Avoca, Penn.

W. V. WHITE

I recently had an experience very much out of the ordinary, in the case of an air pump working on a surface condenser and in my charge as erector for the builders of a municipal pumping engine, built by the Hooven, Owens, Rentschler Co. The air pump was a "Blake" with water cylinder 12 x 12 in., which had a bad "kick" on one end—would do nothing whatever on one end. Two experts came from the makers to examine it. The first wanted different springs put in, which was done, but without results; the second wanted new valves put in, but they did no good. I then put on the indicator and got diagram No. 1. This diagram would be considerable of a puzzle to many operators, but is readily understood when explained. The right-hand end is a fine "air-compressor" diagram (which, in fact, an air pump really is). The valve opening is good and the intake as well, while the compression is ideal and the delivery fine.

The left-hand end is the "sticker"—it has nothing to show but a compression line. The intake runs back on the compression and does not rise high enough to discharge, neither does the intake come to correspond to the suction due to that produced by the other end.



DIAGRAMS TAKEN BEFORE AND AFTER CUTTING HOLES IN DISCHARGE VALVES

The answer to it all is excessive clearance on that end. The pump was handling only some 1800 lb. of water per hour, which was not enough to take up the clearance on both ends, so the smaller clearance took the supply and did the work and allowed the other end to "kick."

Acting on this analysis, some holes were cut in the discharge valves on that end, allowing enough water to leak back to fill the clearance; then diagram No. 2 was taken.

W. V. WHITE.

Hamilton, Ohio.

Paint To Reduce Power-House Accidents

Camouflage was developed to reduce visibility in the war. The reverse of the same principle has been adopted in the plant of the Union Gas and Electric Co., Cincinnati, Ohio, to reduce accidents. In one conduit gallery in the plant where the ceiling is low, a number of angle irons project down to levels at which a man's head is likely to collide with them if he is careless. To make these irons easier to see so that such accidents will be less likely to occur, the company has painted the projecting struts with alternate bands of black and white about three inches wide.

Don't think, because the war is over, that the bills don't have to be paid!

Reconnecting Induction Motors—General Summary

By A. M. DUDLEY
Designing Engineer, Westinghouse Electric and Manufacturing Company

During the last two years a series of thirteen articles have appeared in "Power" on the subject of reconnecting induction motors. It is the purpose of this article to sum up the principles brought out in the series and to give an outline of the practical points that must be considered in deciding whether or not a given motor may be reconnected for different conditions without new coils or core iron.

THE main principles which operate to fix the limits of the different combinations, such as series, parallel, series star, parallel star, series delta, parallel delta, etc., possible with a single winding, may be enumerated somewhat in the following manner:

1. The mechanical output of a motor is limited by the cross-section of copper available to carry current and by the cross-section of iron available to carry magnetic flux.

2. An induction motor is also at all times an alternating-current generator as well, and the voltage generated by its own rotating field cutting the conductors of its own stator coils must at all times very closely approximate the applied line voltage.

3. It is necessary that the pitch or throw of the coils bear some reasonable physical relation to the number of poles that the machine has. For example, in a 4-pole motor the coils should throw somewhere near ¼ of the circumference of the stator bore, in a 6-pole motor

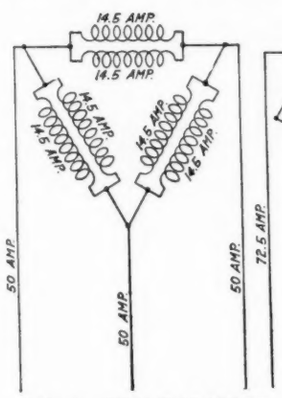


FIG. 1. TWO-PARALLEL DELTA CONNECTION

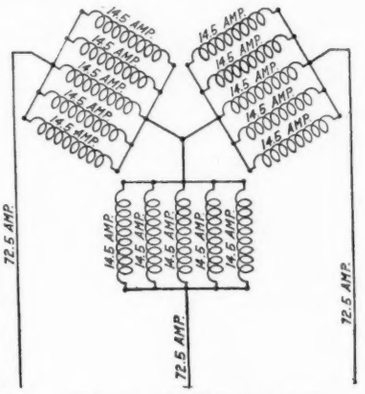


FIG. 2. FIVE-PARALLEL STAR CONNECTION

somewhere near ⅛ the circumference, and so on. The practical limits to the throw are from ½ to 1½ times this full-pitch value. That is to say, in a 72-slot 6-pole motor the full or exact pitch for the coil throw would be $\frac{72}{6} = 12$ slots, or the coil would be in slots 1 and 13. Using the limits ½ to 1½ as given, the throw of the coil should be not less than 6 slots nor more than 18 slots for possible operation; that is, the coils should not spread less than slots 1 and 7 nor more than slots 1 and 19.

4. All changes in operating conditions whether of horsepower, voltage, phases, frequency or poles, may be reduced to terms of change in voltage and so considered.

5. An induction motor is similar to a transformer in that the number of turns in series in the winding must be varied in the same direction and by the same percentage as any change in the voltage applied. In addition to these principles the following practical considerations must be remembered: a. The new voltage which is applied to a reconnected motor must not exceed the limiting value of the insulation which is on the coils. For example, 2200 volts should not be applied to a 550-volt winding even though it has been reconnected with four times as many turns in series.

b. In reconnecting for higher speeds the peripheral speed of the rotor must be kept down to a safe value so that the centrifugal force does not damage the rotor core or winding mechanically.

c. In a wound-rotor motor the rotor winding must be connected for the same number of poles as the stator winding.

d. In a squirrel-cage motor if radical changes are made in the number of poles, a change may also be required in the short-circuiting rings of the squirrel-cage rotor winding in order to keep the proper starting torque.

e. In a polar-group winding the individual coils at the beginning and end of the phase groups have usually heavier insulation than the inside coils of the groups. Where this is the case, when reconnecting for change in phase or poles the coils with the heavier insulation should be shifted to their proper new places in the winding.

These principles have been thoroughly covered in the articles as they appeared, but in recapitulation some additional comments may be made bearing on the practical application.

1. Cross-Section of Copper and Iron—From the existing connection of the winding in the machine which is to be reconnected, it is a simple matter to check the current flowing in the turns of the coils which are in series. This is done by checking the connection of the winding; that is, whether it is series or parallel, star or delta, etc. From this fact and the rated current of the machine can be derived directly the current in the coils themselves. For example, a three-phase machine has a normal rating of 50 amperes per terminal and is connected 2-parallel delta, Fig. 1. The current in the individual coils themselves is $\frac{50}{2 \times 1.73} = 14.5$ amperes, as shown. Then the load which is put on the motor after reconnection should not be greater than that which would cause 14.5 amperes to flow in the coils themselves. Under the new connection the polar groups might be

5-parallel star, as in Fig. 2, in which case the new current per lead would be 5×14.5 amperes $= 72.5$ amperes, but the current in the individual coils would still be 14.5 amperes as indicated.

If the new connection is for a greater number of poles and hence a slower speed, it would be well not to put quite so much current through as originally on account

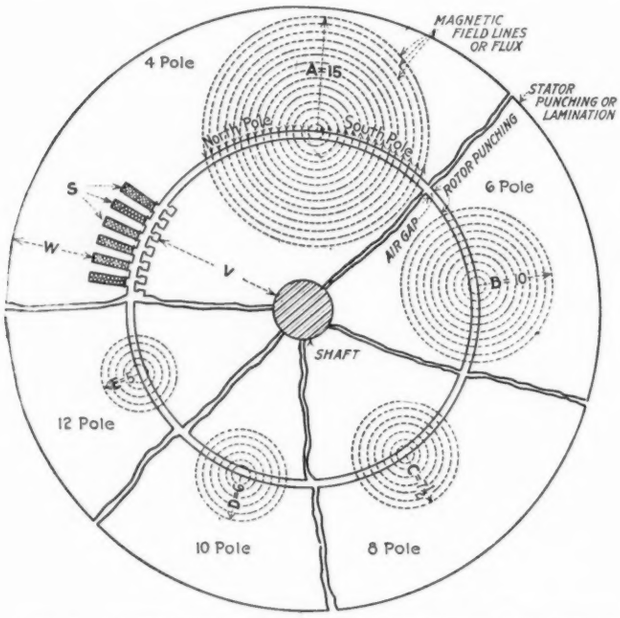


FIG. 3. CORE SECTIONS SHOWING EFFECT ON MAGNETIC FIELD BY CHANGING NUMBER OF POLES

of the reduction in ventilation. Regarding the cross-section of iron, this remains constant so far as the teeth are concerned, but in the core back of the slots this changes with the number of poles. This is illustrated by Fig. 3, which shows a cross-section of a motor indicating the magnetic conditions in the iron when the motor is connected for 4, 6, 8, 10 or 12 poles.

Considering the 4-pole sector, the coils in the stator slots *S* set up a magnetic field represented by the 15 concentric circles causing a north pole where they leave the stator and a south pole where they reënter the stator, as indicated by the arrowheads. The proximity of these 15 circles at the air gap indicates the density of the magnetic field at this location. It will be noted that all 15 of these circles must pass through the core back of the slots or through a cross-section represented by the dimension *W*.

If, now, consideration is given to the sector marked 6-pole, it will be noticed that the magnetic density in the air gap as indicated by the proximity of the concentric circles is the same as in the case of 4 poles, but the iron back of the slots now has to carry only 10 circles and hence has only $\frac{10}{15}$ the magnetic density as in the case of 4 poles. There is still the same total flux in the machine, since $4 \times 15 = 60 = 6 \times 10$, and this explains why the air-gap density stays the same, but this total flux is now separated into six magnetic circuits instead of four and hence the iron in the core back of the slots is not worked nearly so hard.

Similarly, in the case of 8 poles there are only $7\frac{1}{2}$ circles, since $8 \times 7\frac{1}{2} = 60$, and in the case of 10 poles 6 circles and 12 poles 5 circles, since $10 \times 6 = 60$ and $12 \times 5 = 60$. In other words, there is the same total flux in the machine for all these connections and the same magnetic density in the air gap, but the core iron back of the slots works at a higher density the smaller the number of poles and at a lower density the larger the number of poles for which the winding is connected. The obvious precaution to be drawn from this consideration is that when reconnecting a winding for a smaller number of poles some check should be made to insure that the magnetic density in the core does not exceed a safe value. Reference will be made to this in a future article on estimating a new winding for an old core.

2. Generator Action of the Winding—This has been referred to several times and will not be elaborated here beyond calling attention to the fact that the rotating magnetic field will always assume such a value that as it cuts the stator coils it will generate in them a voltage practically equivalent to the applied line voltage. Since both the number of turns in series in the coils and the magnetic density in the iron may be varied, there are evidently several combinations that would generate the line voltage, some having more turns and less field and some having less turns and more field. The practical difference between these combinations would be that the fewer the turns and the stronger the field the greater would be the maximum torque, this being limited by the saturation of the iron in the core. A little thought brings out the fact that this is equivalent to raising and lowering the voltage on a fixed winding. The higher the voltage the greater will be the magnetic field and the greater the torque. This consideration of the generated voltage or counter-electromotive force or back electromotive force is one of the

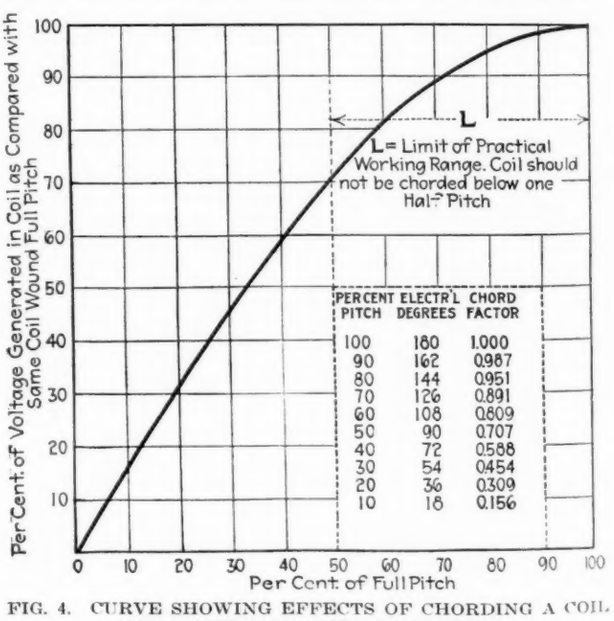

Per Cent. of Voltage Generated in Coil as Compared with Same Coil Wound Full Pitch
Per Cent. of Full Pitch
L
L= Limit of Practical Working Range. Coil should not be chorded below one Half Pitch
PERCENT PITCH
ELECTR'L DEGREES
CHORD FACTOR
100 180 1.000
90 162 0.987
80 144 0.951
70 126 0.891
60 108 0.809
50 90 0.707
40 72 0.588
30 54 0.454
20 36 0.309
10 18 0.156

FIG. 4. CURVE SHOWING EFFECTS OF CHORDING A COIL UPON THE VOLTAGE GENERATED

simplest checks on the number of turns required in a winding.

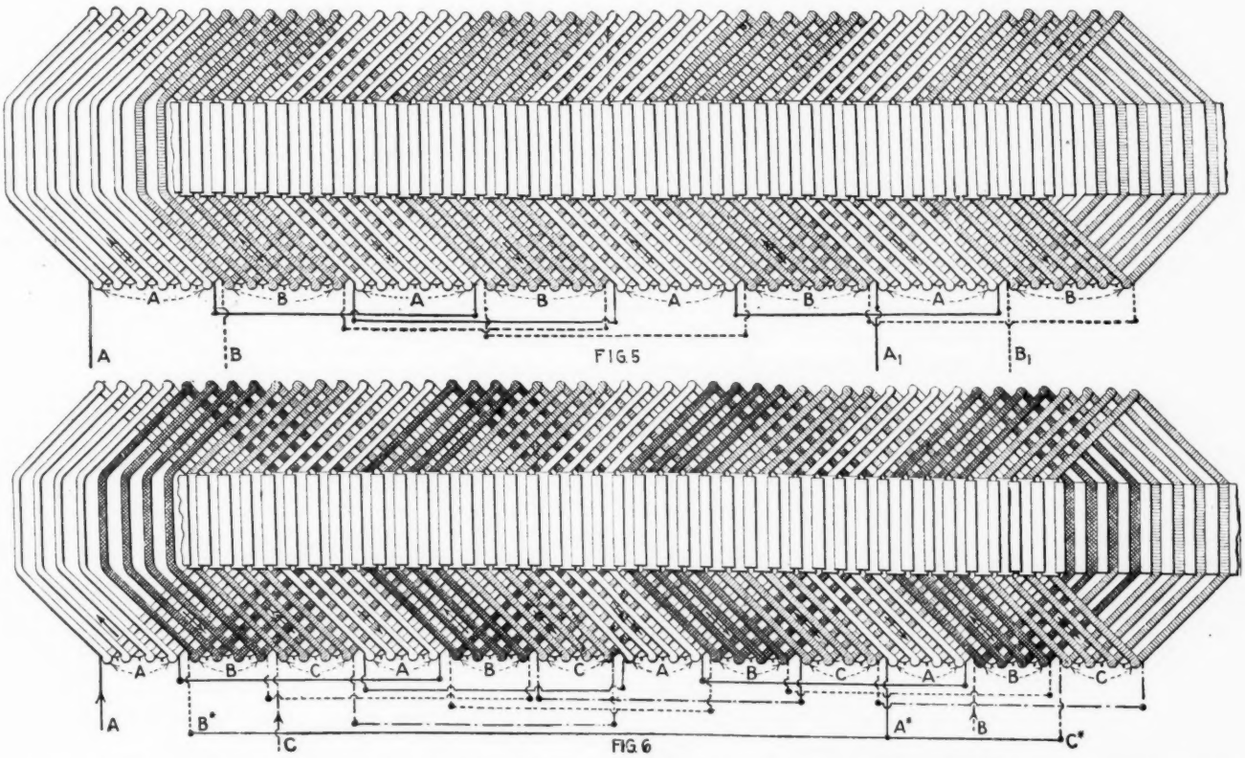
3. The effect of changing the throw has been thoroughly covered, and only the effect on the applied voltage will be shown here as a curve, Fig. 4. In this figure full pitch is called 100 per cent. For example, in a 72-slot 6-pole motor the winding would be 100 per cent. pitch if the coils lay in slots 1 and 13, it would be $66\frac{2}{3}$

per cent. pitch if the coils lay in slots 1 and 9 or 50 per cent. if they lay in slots 1 and 7. The curve indicates how the voltage applied to a coil or a winding should be reduced as the coil is chorded up if the same magnetic conditions are to be kept, or the reciprocal of the curve values indicates how the density of the magnetic field will increase if the voltage is held constant while the throw of the coils is decreased.

4. The statement is here made that any change in the operating characteristics of a motor may be reduced to terms of a voltage change and that if the corresponding voltage be applied the operation under the new conditions will approximate the normal operating conditions under the original conditions. Since there are five main operating characteristics—namely, volts, phase, poles, cycles and horsepower—a brief résumé is in order stating how each one of these may be considered as a voltage change. In other words if, for example, the horsepower or phase of a motor is to be arbitrarily changed, what will be the new operating voltage to secure this result? Taking these characteristics in order, a voltage change is self-evident since everything is to be reduced to voltage. In the case of a phase change, two to three or vice versa, the voltage on a three-phase connection should be $\frac{5}{4}$ of that on th corresponding two-phase connection. For example, if a two-phase motor is connected for three-phase and everything else left the same, the three-phase connection should be operated at $\frac{4}{5}$ the rated voltage of the two-phase, or a two-phase 440-volt motor when reconnected for three-phase becomes a 550-volt motor, etc. In Fig. 5 is shown a 48-coil induction-motor winding grouped for two-phase 4-poles, if this winding will operate on 440 volts two-phase it will also operate on 550 volts three-phase when grouped 4-pole series star, as in Fig. 6.

In the case of a change in the number of poles, if the voltage be changed in the same direction and by the same amount as the change in speed, the torque will remain essentially constant and the horsepower will vary with the speed, being greater at higher speed and less at lower speed in exact proportion. However, if for reasons explained in connection with Fig. 3, there is not enough iron back of the slots to permit of keeping the same total flux and dividing it into fewer circuits with greater flux per circuit, the voltage may be kept constant and the horsepower will remain practically constant. The latter condition would mean that there is less total magnetic flux and less torque at higher speeds and greater total flux and greater torque at lower speeds, as must necessarily be expected since the horsepower is constant and horsepower = torque × r.p.m. ÷ 5252.

A varying frequency can be readily reduced to a corresponding voltage change by remembering that a change in frequency without any other change would result in a change in speed and since the basic idea of this method is that the motor is also an alternating-current generator, generating the applied voltage, it is evident that with an increased speed the generated voltage will be increased and with decreased speed the generated voltage will be decreased. Hence, it follows directly that when the frequency or cycles of the supply circuit are changed the voltage should be changed by the same amount and in the same direction. For example, if a 60-cycle motor is run on 50 cycles it should have applied only $\frac{5}{6}$ the voltage if the same magnetic condition is to be kept, and consequently the horsepower will



FIGS. 5 AND 6. TWO-PHASE, FOUR-POLE INDUCTION MOTOR WINDING CONNECTED SERIES AND THREE-PHASE, FOUR-POLE INDUCTION MOTOR WINDING CONNECTED SERIES STAR

be only ⅔ of the 60-cycle value. Viewed mechanically, the torque remains the same on 50 cycles, but the speed is only ⅚ as great, hence there is only ⅚ the horsepower which checks the electrical result.

There remains only a change in horsepower to be converted into a voltage change, and this is apparent from the fact that in any motor the horsepower is proportional to the product of the voltage and amperes. Since the cross-section of the copper conductor remains the same and hence the amperes remain the same, the only thing that can vary is the voltage, and it follows directly that to get more horsepower out of a motor requires the application of a higher voltage and less horsepower will permit the use of a lower voltage.

From these considerations it appears that the effect of a change in any of the characteristics of the motor can be balanced by the proper change in the voltage. This statement at once arouses the comment that while it might be found that 273 volts or 346 volts or something of the kind was proper to give normal operation on a motor under changed conditions of phase or poles or what not, still such information would be of little use since there are no commercial circuits having such voltage values. The answer to this is that the number of turns in the winding or the connection of the groups may be changed so as to increase the total number of turns in series by the amount that the voltage should be decreased; and vice versa, it may be possible to decrease the total number of turns per phase in series by the amount that the voltage should be increased.

(The next article will treat a number of practical problems showing how the foregoing may be accomplished.)

Ventilation of Ammonia Condensers

By T. S. SIEBEN
Cooling Plant Inspector, City of Chicago

Types of housing for atmospheric condensers that direct the air through the stands of pipe to carry away the vapor and permit repairs to pan and roof without disturbing the equipment.

IN THE last few years great developments have been made in ammonia-condenser construction, but often little thought is given to the housing with a view toward attaining the maximum results in operation. The following remarks deal principally with the surface condenser with a preliminary brief review of other types.

Submerged condensers are now practically obsolete. That this condenser was constructed on the countercurrent principle—that is, the coldest water meeting the coldest vapor—and was considered the safest in operation were features given in its favor. On the other hand, it was unwieldy and required a great amount of water. These condensers were generally located indoors close to the compressors, and the open top was usually placed in line with windows to provide for ventilation.

Shell condensers of the early type had cast-iron shells and heads with helical water coils. More modern types are made of steel with welded joints and straight water tubes, the water heads being baffled to provide a multipass arrangement effecting good heat transfer. The construction of the shell type condenser favors minimum friction in the passage of the vapor, thereby keeping the pressure close to theoretical, corresponding to the temperature of the cooling water. Usually, these condensers are placed indoors and no special ventilation is required.

Double-pipe condensers are constructed on the counterflow principle and are usually placed indoors, close to the compressor, making a compact unit. The cooling water passes through the inner pipes and from there is carried off without any vapors being released. In small plants little heat is radiated into the room, but for large outfits ventilation should be provided, the condenser being safeguarded against freezing in the cold weather.

Atmospheric condensers are usually installed in large plants and operate to a great extent on the principle of the cooling effect produced by the evaporation of part of the cooling water when passing over the coils. The usual forms of atmospheric condenser do not favor the counterflow principle; however, some types embody this feature or a compromise in the form of a forecooler. One form of atmospheric condenser developed in the last few years is the flooded type, in which part of the liquefied vapor is reinjected into the condenser and mixed with the incoming dry vapor from the compressor. The wet vapor thus formed tends to produce a heat transfer twice or three times that obtained under the usual conditions.

As a great amount of vapor is released when the cooling water is passed over the condenser, some means

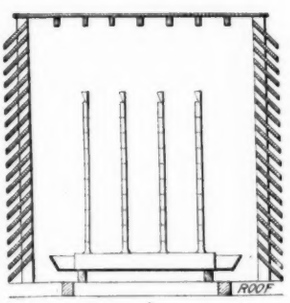


FIG. 1. CONVENTIONAL HOUSING FOR ATMOSPHERIC CONDENSER

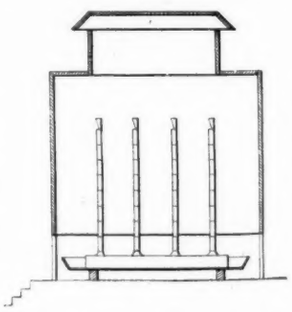


FIG. 2. INTRODUCTION OF CUPOLA OVER CONDENSER

of ventilation should be provided. It is customary to place these condensers outdoors or on the roof of a building, preferably shielding them from the sun.

Fig. 1 shows a conventional form of condenser house. The walls are built of louvre work and the entire structure is covered by a tight roof. This construction is based on the theory that the air has access to the condenser from all sides, but as the section on the windward side checks the draft, this supposition does not

hold good. The defect in this form of construction can be noticed on cold days when the sluggish vapors are visible near the ceiling. These vapors tend to corrode the condenser and rot the woodwork. A cooling tower is sometimes placed above, and while it cools the water, it does not help to relieve the vapor situation. If a cooling tower is necessary, it should be placed on a separate structure. Some relief from the vapor can

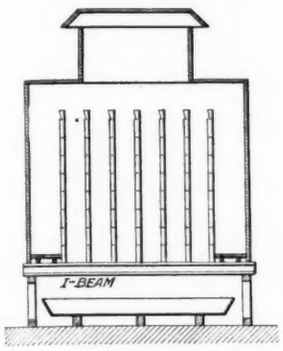


FIG. 3. CONDENSER RESTING ON STEEL BEAMS ABOVE PAN

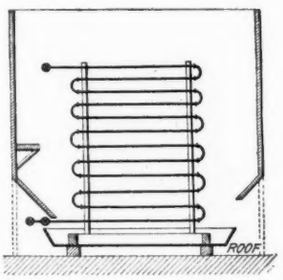


FIG. 4. INEXPENSIVE HOUSING WITHOUT ROOF

be obtained by cutting holes in the roof or better still, by placing a cupola over the condenser to allow the vapors to escape.

Fig. 2 provides for walls closed in on all sides, excepting that the bottom three or four feet are open all around and a large cupola construction placed on the roof. This will permit air to enter at the bottom and rise with the natural flow of the warmer vapor. The condenser rests in a pan on the floor of the condenser house, and the entire structure is raised a few feet so that repairs may be made to the roof.

A variation of construction is shown in Fig. 3. Here the condenser is erected on a framework of steel beams instead of the usual method of placing it in the pan. This allows repairs on the pan to be made without the necessity of disturbing the condenser. Open spaces about the condenser can be filled in by planks so that all entering air must come in contact with the stands of pipe. This design, without the water pan, can be used also for double-pipe condensers, provided steps are taken to prevent freezing.

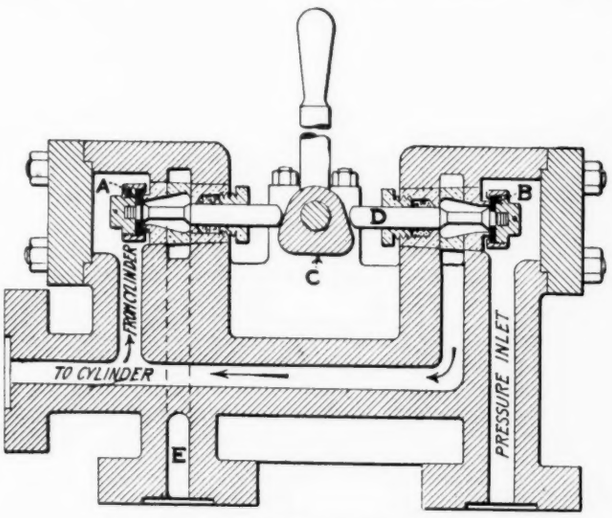
An idea successfully carried out as indicated in Fig. 4 compels the admission of air from under the diagonal bulkheads shown, which protect the liquid and pump-out valves and the headers from flying spray. Overhead gas-inlet valves can be conveniently reached from a runway within the structure. No roof is placed over the condenser and the walls need be only high enough to keep the sun off the pipes. This construction is perhaps the least costly of all to build.

It has been demonstrated that with a suitable form of condenser housing a great saving can be effected in water and power bills and that the head pressure may be lowered to a safer working condition. Under moderate working conditions, due to the lower pressure, and particularly if a liberal-sized condenser is employed, the cooling water can be re-used without passing through a cooling tower. In freezing weather the condenser can often be operated dry without unduly raising the vapor pressure.

Hydraulic Operating Valve

Hydraulic operating valves are used for various purposes where hydraulic pressure is the medium for moving a piston in a cylinder. A new operating valve, recently placed on the market by the Vance-Vetter Co., Pittsburgh, Penn., contains, as its principal feature, a flat disk made from either leather or fiber, which can be easily renewed without disconnecting the valve or piping. This feature is shown at *A* and *B* in the illustration.

In operation, the water pressure enters the valve through the pressure-inlet connection, but cannot pass through while the handle remains in the central or upright position. Pushing the handle forward to the open position brings the cam *C* against the valve stem *D* and forces the valve *B* from its seat, allowing the pressure to pass through the valve opening into the part leading to the cylinder. Pulling the handle back to the central position allows the inlet pressure to close the



SECTION THROUGH OPERATING VALVE

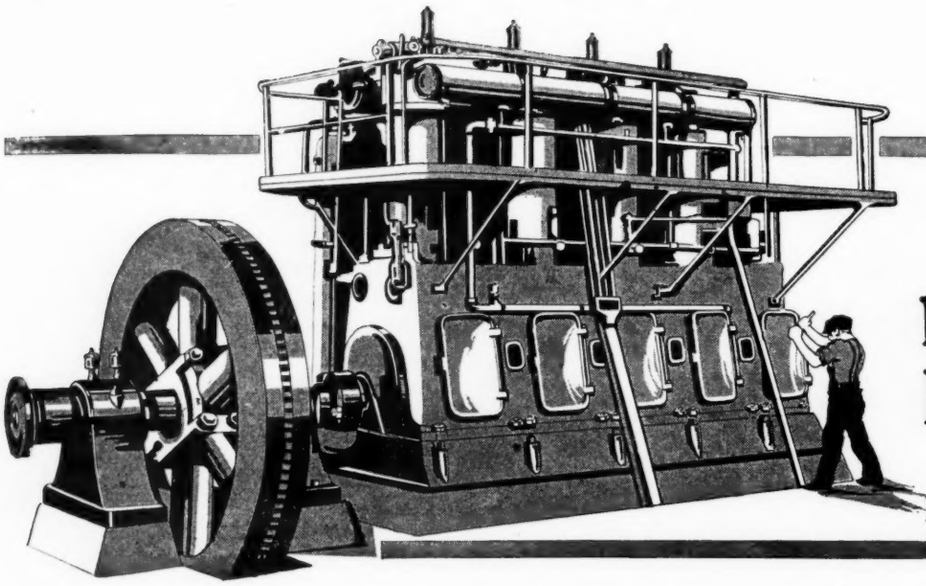
valve. When the handle is moved back beyond the central position, the cam *C* opens the valve *A* and allows the return water to come back through the same pipe and discharge through the valve opening, to the waste-water outlet *E*.

As the valves are operated by a cam movement, they have a positive stop for open and closed positions and cannot creep. When the handle is released to the center position, it centers and closes the valve automatically.

This valve is designed for pressures up to 3000 lb. per sq.in. and will work without sticking with muddy or sandy water.

If the rotative speed of an engine is increased, other conditions remaining unchanged, the quantity of steam used per horsepower per hour will decrease. This is because there is less time for heat transfer between the cylinder walls and the steam and also for the loss of heat through radiation.

If the ammonia charge in an absorption system contains 0.6 per cent. or more of carbon dioxide, a sludge of black iron oxide mixed with free carbon will be formed by the action of oxygen on the iron pipes.



Talks on DIESEL Engines

by L. H. Morrison

XI—Takes up the construction and action of fuel valves of various forms and points out how to care for such valves.

"WHAT one thing about fuel valves bothers you most?" was Egan's general inquiry at the opening of the next meeting.

Woods was ready to seize the opportunity.

"Why is air used to blow the oil into the cylinder?" he asked. "Why not shoot it straight from the pump, as in the hot-ball engine?"

"Impossible," Egan replied. "In a hot-ball engine the compression is low and the temperature won't explode the oil prematurely, so that pump injection is possible. But in a Diesel the compression temperature is high and at heavy loads may be high enough to ignite an oil charge early in the stroke, so that pump injection would be dangerous. If a cam-operated needle valve is placed between the pump and the nozzle, however, pump injection can be used. The main difficulty is that it takes a pressure of about 2500 lb. per sq.in. to atomize the oil."

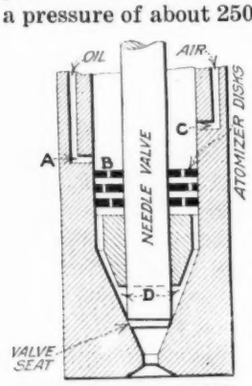


FIG. 1. CLOSED TYPE OF FUEL NOZZLE

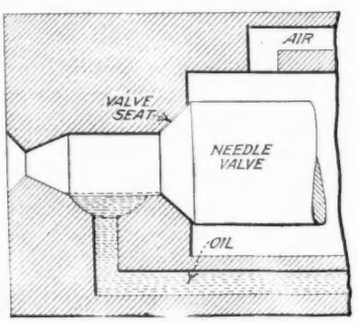


FIG. 2. OPEN TYPE OF FUEL NOZZLE

"First thing, J. R.," Kelly broke in, "I want you to explain the meaning of open and closed nozzles. The other day a salesman dropped in, and he spoke of his engine using an open nozzle. He had my number on that, but I didn't care to show myself up as a sort of ignoramus by asking what he meant."

"Kelly, the air-fuel injection systems, as we will call them, can be separated into two classes. The first employs a fuel valve where the oil is deposited by the pump, in contact with the highly compressed air, behind the needle valve. That is, the needle valve is between the

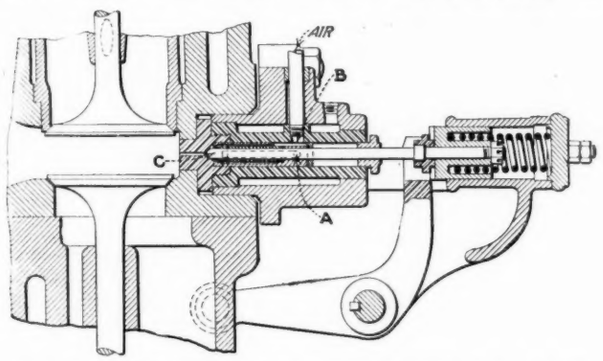


FIG. 3. CLOSED TYPE OF NOZZLE USED ON EARLY AMERICAN ENGINES

combustion chamber and the fuel charge. When the needle valve opens, the air blows the fuel past the valve seat into the combustion chamber. Fig. 1 shows the closed nozzle and the open type is outlined in Fig. 2. In the latter the fuel is deposited beyond the needle valve and is in open communication with the combustion chamber. When the needle valve opens, the air current picks up the oil and blows it into the cylinder.

"The closed type has been in longer use and has been adopted by the majority of builders, so we'll take up a few examples of the closed nozzle. First let us take the one used on our American engine, as it is the forerunner of those used on American engines. Fig. 3 is a cross-section of the valve body and parts. The oil is fed in horizontally at *A* and flows along to a point just behind the valve seat. The air enters at *B* and is behind the oil charge. When the needle valve *C* opens, the air blows the oil through a row of minute ports into the nozzle passage. A sketch of the atomizer is given in Fig. 4. The fault of this atomizer ap-

At the next meeting the chief will talk to the class about the construction of fuel pumps and their operation

pears to be that the passage of the oil through the ports doesn't provide enough atomization. If the load is light and the charge small, there is no atomization, so we needn't be surprised if the engine smokes on light loads. Another defect is that the lack of resistance in the atomizer lets too much air blow through on light loads. I'd be willing to bet that twice as much air is used on light as on heavy loads, when the air pressure is kept the same. The result is that the output of the engine is low in comparison with the indicated horsepower. If the load

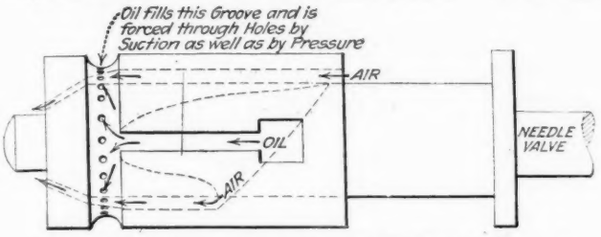


FIG. 4. ATOMIZER OF NOZZLE SHOWN IN FIG. 3

is continuously light, the air pressure should be reduced by throttling the air-compressor suction and cutting out the air-bottle line.

"The majority of closed nozzles are similar to the simple form in Fig. 1. The oil passes down the passage *A* to a position over the atomizer *B*. The air is forced through the port *C* into the valve body above the oil. The atomizer consists of a series of perforated disks with the holes staggered. The oil, on entering the valve cavity, flows down through the disks and fills the spaces in the atomizer as well as the passages *D* behind the valve seat.

"The governing is effected, almost without exception, by regulation of the fuel deposited in the valve, although a few have experimented with the plan of varying the opening of the fuel valve. The atomizer serves a double purpose—to atomize the oil and mix it with the air and to control the flow of air and oil so that the entire

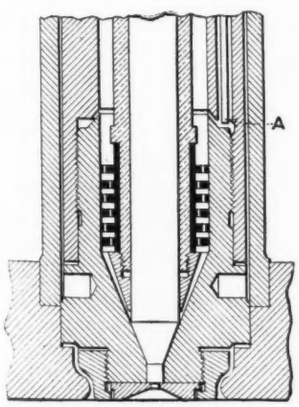


FIG. 5. FUEL NOZZLE OF BUSCH-SULZER ENGINE

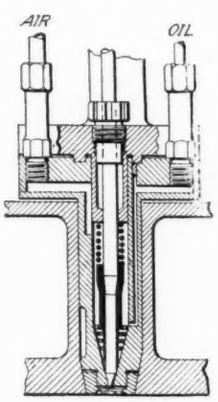


FIG. 6. FUEL NOZZLE OF FULTON ENGINE

charge will not enter the combustion chamber when the valve first opens. This latter effect is called 'braking' and is probably the more important of the two."

"Chief, what engines use that kind of atomizer?" Woods inquired.

"As I stated, a great number use some similar design. The cross-section, Fig. 5, is of the Busch-Sulzer valve."

"Mr. Egan, what is that rod *A* for? I saw it the other day when we had one of the valves out, and even Kelly didn't know the why of it." The Scotsman asked the question.

"That is a dandy little scheme, and every engine ought to have some such arrangement. That rod is made of aluminum and rests in the oil line. If the fuel is a very light distillate, the temperature of the

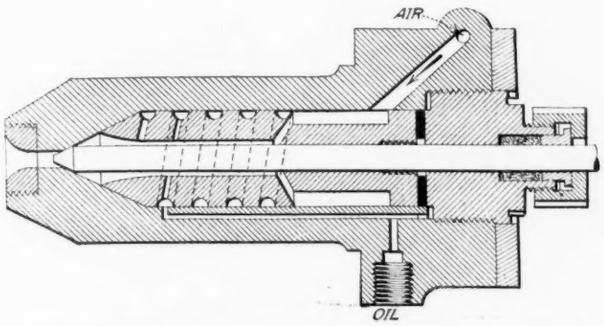


FIG. 7. FUEL NOZZLE FOR HORIZONTAL ENGINES

valve body might cause carbonization. This little rod shakes around due to the vibrations of the engine and so keeps the passage clear. When a heavy oil is used, quite often a sediment will deposit in the passage, and this wiggling stick acts as a policeman, keeping the oil traffic on the move down the passage."

"Well, J. R.," asked Kelly, "what's your kick against this kind of valve?"

"You fellows mustn't get the idea I'm a chronic kicker," protested Egan. "I merely take the stand that the bad features should be pointed out. The good points show up in the continued operation of an engine. But I don't intend to allow Kelly's snarky question to stop me. All valves built along the line of this one need improvement. When the oil charge is large, as on heavy loads, it is forced down through the atomizer by the air and fills the entire space in the atomizing disks as well as the space behind the valve seat. When the valve opens, the oil just behind the valve at once flows into the cylinder without being broken up, and the combustion is imperfect. The braking effect on the air and oil mixture that passes through the disks is increased due to the greater resistance. The combustion is drawn out over a longer period than is desirable, and the combustion line on the indicator card is sloping rather than fairly horizontal.

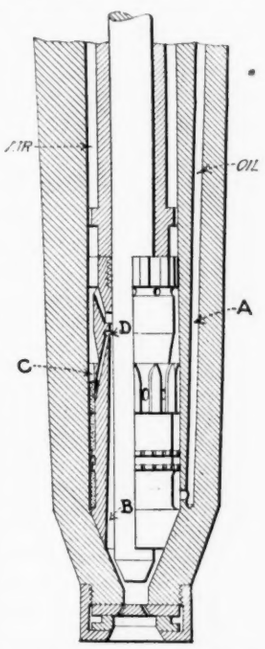


FIG. 8. HESSELMANN ATOMIZER

"Now take the case where the fuel charge is light. It does not flow so readily through the disks owing to its lighter weight, and so does not displace the air below the disks. When the valve opens, the trapped air is first to enter the cylinder. This cools the combustion chamber and delays the burning of the fuel that follows. Furthermore, since the fuel charge is smaller,

it enters the cylinder at a higher rate and of course in a shorter time. Then during a considerable part of the time the needle valve is open, nothing but air blows through the atomizer. The braking action of the

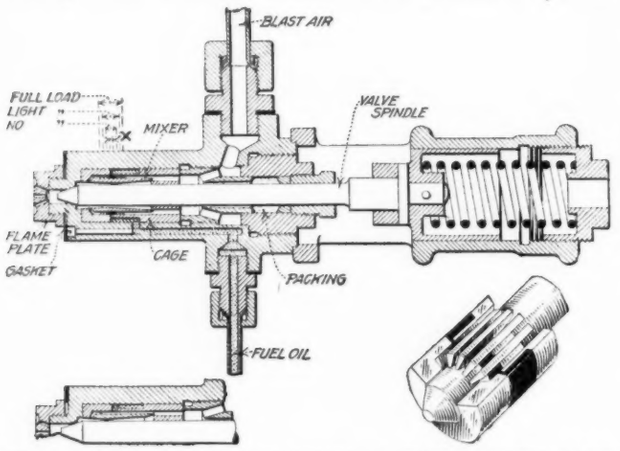


FIG. 9. NOZZLE USED BY GENERAL ELECTRIC COMPANY

atomizer has but little effect on the air, and a far greater amount of air enters the combustion chamber than in case of full load. This is the reason that on low loads the actual friction horsepower is more than on full load. The nozzle used in the Fulton engine is shown in section in Fig. 6.

"If we increase the air pressure, or decrease the resistance of the atomizer, the rate of flow will increase. So it could well be expressed by an equation:

$$\textit{Rate of injection} = \frac{\textit{pressure difference}}{\textit{resistance of atomizer}}$$

"The pressure difference is the difference between the injection-air pressure and the cylinder-compression pressure. This equation indicates, then, that if the resistance is kept constant, the only way to vary the rate of injection is by varying the air pressure, as by the use of an automatic device. In engines not having automatic adjustment, the pressure variation can be secured by hand adjustment of the compressor intake. This applies only when the load does not swing, and of course an operator can only care for those load variations that are of considerable duration.

"Another fact worth remembering is that the resistance of an atomizer bears no relation to the degree of atomization secured. It's apparent that the disk form of atomizer has a great resistance and for the same rate of injection the pressure must be kept higher than in the case where the resistance is low. The main object is to secure low resistance with high atomization, so as to lower the compressor horsepower.

"Fig. 7 is the fuel valve used on horizontal engines, or in a horizontal position on vertical engines. The fuel is introduced into the spiral close to the needle valve. The greater the oil charge, the farther the fuel backs up in the spiral. The air passage allows an expansion of the air with a pressure reduction, as the valve opens. This pressure difference forces the oil into the air with fair atomization. The resistance of the atomizer varies with the oil charge. With a heavy charge the oil will flow down around the valve seat and the first particles entering the cylinder will be poorly mixed.

"Fig. 8 outlines the Hesselmann atomizer used on the McIntosh & Seymour engine. The oil flows down the passage *A* shown and is deposited around the atomizer, as indicated by the stippled area in the cross-section. As the valve opens, the air sweeps down along the valve stem, and as the passage *B* has an increasing cross-section, the pressure decreases. The air, at full pressure, rests on the oil at *C* and this unbalancing of pressures causes the oil to start to flow toward the valve stem at *D*. Once this action is set up, the entire charge of oil is supposed to be drawn into the air stream by an injector effect, but in practice this is not achieved to entire satisfaction. Part of the oil remains at the bottom. On the next charge, if it is full load, the oil level rises and overflows into the air passage around the valve stem. The result is that some oil collects around the valve seat or blows into the cylinder unatomized. The big advantage of this type of valve lies in its low resistance, and this means a lower injection air pressure. Fig. 9 is a valve used by General Electric Co. that uses the same principle of unbalanced air pressure.

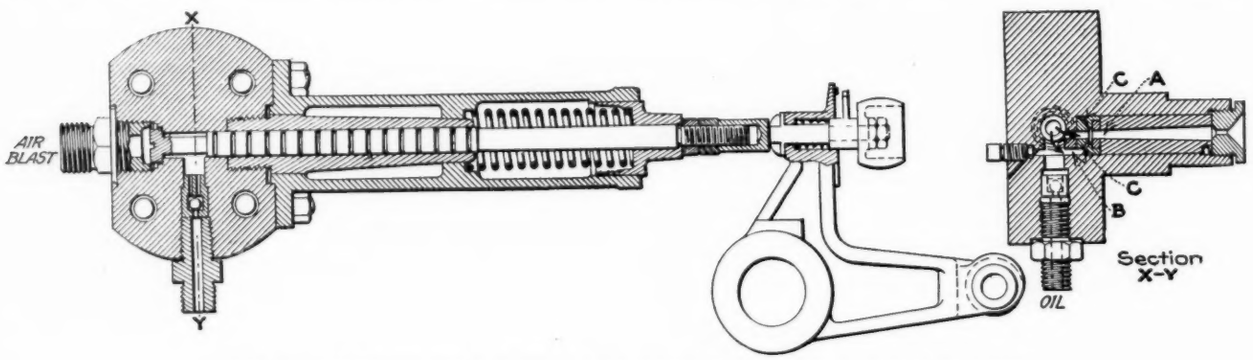


FIG. 10. TYPE OF FUEL VALVE AND NOZZLE USED ON McEWEN ENGINE

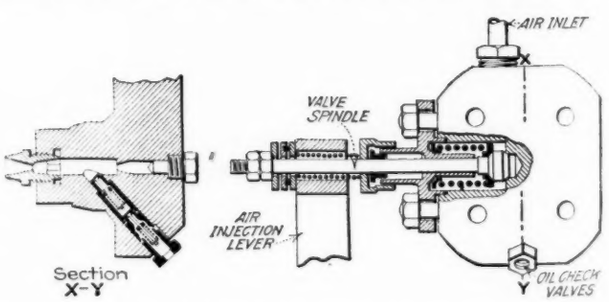


FIG. 11. FUEL NOZZLE OF ALLIS-CHALMERS ENGINE

"Coming now to open nozzles, Fig. 10 shows the valve used in the McEwen engine. Part of the air charge passes directly through the central opening into the tube *A*, as indicated by the arrows in the section *XY*. The expansion taking place causes the resulting unbalanced air pressure at *B* to force the oil through the ports *C* into the tube, where it mixes with the air.

"Fig. 11 outlines the Allis-Chalmers nozzle, which is also of the open type."

"What's the advantage of this kind of valve, chief?" Kelly asked.

"Well," Egan replied, "it has a low resistance, so that it's possible to use an air pressure at least 15 per cent. lower than that used with a closed nozzle. There is no highly compressed air in contact with the fuel. If the oil should ignite prematurely, no great damage can be done, as the oil receptacle is in communication with the cylinder. It would be practically impossible to make it burn since it is surrounded by foul gases instead of pure air. But the open nozzle has disadvantages, too. The atomization is far from perfect, and the oil is delivered to the cylinder in slugs rather than in minute particles. In fact, the only atomization that takes place occurs at the nozzle tip. There is a tendency toward smoking due to this poor mixing of the air and the oil.

"Getting down now to practical operation, the valve should be cleaned once every month. Don't let yourself be kidded by the quiet running of the engine into neglecting this. To clean the valve, soak all the parts for a couple of hours in kerosene. Then clean each passage and corner thoroughly with a thin steel bodkin. The valve should be ground. This is a particular job and should be carefully done. Often the valve stems pit owing to sulphur in the oil. If this occurs, use emery cloth and put the surface in good shape. In packing the valve stuffing-box, use shredded lead. You can buy it from a supply house and it beats any other packing I know. It's also very necessary to maintain a good spring pressure. If regrinding has shortened the length of the stem, you can slip a washer above the spring and tighten it down with the adjusting setscrew."

"Chief, why is the nose of the fuel cam adjustable?" Woods asked.

"You will find that different oils require different periods of injection, and the adjustable nose allows the point of injection to be varied. Another thing—the wear on fuel cams is much more than on the exhaust- and inlet-valve cams, and the adjustable nose allows this wear to be corrected.

"Now, boys, it's late and I'll speak of only one more thing, the method of going about setting valves.

"When a new engine is installed, a good many manufacturers supply prints showing the valve setting. In case you have such a print, set the needle valves first. To do this, unscrew the plug in the exhaust elbow and block open the exhaust valve, or remove the indicator plug on the cylinder. Now turn your engine in the direction of rotation, and crack the air-line valve. When you have rotated the flywheel to the point at which the needle valve should open, if the valve is properly set, you can hear the air rush out through the nozzle. Turn the engine over slowly and see if the valve closes properly. If the point of opening is wrong, adjust the movable cam nose. Then turn the engine backward a considerable distance and bring it forward slowly."

"What's the reason of turning backward?" one of the men put in.

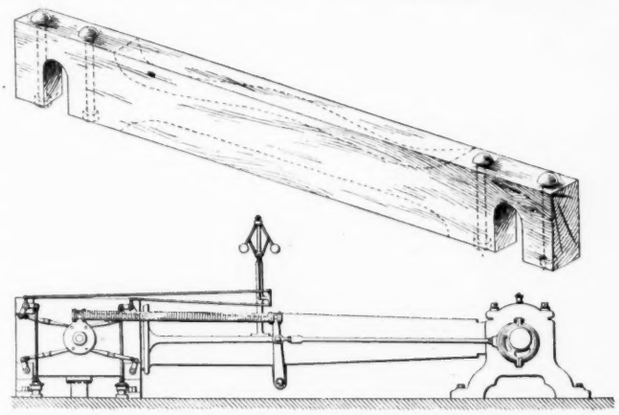
"That's to take up the effect of backlash in the gears. After getting the opening correct, test for point of closure. If this is wrong, it is possible to grind the cam nose to correct it. Before doing so, it's a good plan to check all the valves. Then if they are all out, it may be possible to either advance or retard the position of the cams by changing the gears by one tooth. After you have checked the fuel valves, take up the exhaust and the admission valves."

"Chief, I notice you check all the valves as they come when turning the engine over," spoke up Kelly.

"That is true, and it's quicker to do it that way; but for a beginner it's best to check them as I have just described."

Engine Repair Kept Mine Plant Running

The accompanying illustration shows an emergency repair to a Corliss engine. The rod transmitting motion between the rocker arm and the wristplate broke in such a way that it could not be repaired readily at the mine plant. The master mechanic was hurriedly



EMERGENCY REPAIR TO CORLISS ENGINE

called. In the course of a comparatively short time he had ascertained the exact distance between the rocker-arm and wristplate pin centers, and the diameters of these pins. This distance center to center he laid out accurately on an oak plank of suitable dimensions.

About this time a carpenter that he had sent for arrived with a brace, an expansion bit, a square and a saw. First, holes of the diameter of the two pins were bored at the center points previously determined. The portion of the plank lying between these holes and one edge was then cut out, making a round-bottomed notch. The plank was then slipped over the pins on the valve gear and the engine started.

A new rod was of course immediately ordered. At the first opportunity the carpenter trimmed up the plank-valve rod substitute to the outline indicated by the dotted lines in the illustration. This rendered the plank much lighter, while leaving ample strength to work the wristplate. Two small carriage bolts were also added at either end to prevent splitting.

This wooden rod, while it looked sufficiently ungainly to jar upon the nerves of any artistically inclined power-plant man, kept the engine running and prevented a shutdown until the new rod arrived. It was then stored away against a future emergency.

Areas of Segments of Boiler Heads

To do away with tedious formulas and long calculations tables are given by which the area of a segment of a boiler head to be stayed may be found directly with sufficient accuracy for all practical purposes.

THAT part of the flat head of a boiler between the upper row of tubes and the shell is a segment of a circle, and its area must be found in order that proper provision may be made for staying. The tubes are assumed to offer sufficient support for a distance of 2 in., and the flange of the head is assumed to support the head for a distance that varies according to the thickness of the plate and the pressure to be carried.

The latest revision of the A. S. M. E. Boiler Code states that the area of a segment to be stayed shall be the area inclosed by lines drawn 2 in. from the tubes and at a distance d from the shell, as shown in Figs. 1 and 2. The value of d to

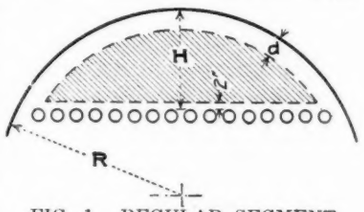


FIG. 1. REGULAR SEGMENT ABOVE TUBES

NET AREAS OF SEGMENTS OF

(H-d-2) Inches	Values of the Term																											
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	31½
3	22	24	26	28	30	31	33	34	35	37	38	39	41	42	43	44	45	46	47								
3½	27	30	32	35	37	39	41	43	44	46	48	49	51	52	54	55	57	58	59								
4	33	36	39	42	45	47	50	52	54	56	58	60	62	64	65	67	69	70	72	74							
4½	39	43	46	50	53	56	59	61	64	66	69	71	73	76	78	80	82	84	86	87							
5	45	49	54	58	61	65	68	71	74	77	80	83	86	88	91	93	95	98	100	102	104	106	*Areas of Segments To Be*				
5½	51	56	61	66	70	74	78	82	86	89	92	95	98	101	104	107	110	112	115	117	120	122					
6	57	63	69	74	79	84	88	93	97	101	104	108	111	115	118	121	124	128	131	133	136	139	141				
6½	63	70	77	83	88	94	99	104	108	113	117	121	125	129	133	136	140	143	146	150	153	156	159				
7	69	77	84	91	98	104	110	115	120	125	130	135	139	144	148	152	155	159	163	167	171	174	178				
7½	75	84	93	105	108	114	121	127	133	138	143	148	154	158	163	168	172	176	181	185	189	193	197	200	204		
8					117	125	132	139	145	151	157	163	168	174	179	184	189	193	198	203	207	211	216	220	224		
8½					127	135	143	151	158	165	171	177	183	189	195	201	206	211	216	221	226	231	236	240	245		
9					137	146	155	163	171	178	185	192	199	205	211	217	223	229	235	240	245	251	256	260	265	270	273
9½					147	157	167	176	184	192	200	207	215	222	228	235	241	248	254	260	266	272	276	280	283	286	289
10					157	168	178	188	197	206	215	223	231	238	246	253	260	266	273	279	286	292	298	304	310	315	318
10½					167	180	190	201	211	220	230	238	247	256	264	271	278	285	293	300	306	313	319	326	332	338	341
11								214	225	235	245	254	263	272	281	289	297	305	313	320	327	334	341	348	355	362	368
11½								227	238	249	260	270	280	290	299	308	317	325	333	341	349	357	364	371	378	386	389
12								240	252	264	276	286	297	307	317	326	336	345	354	362	371	379	387	395	402	410	414
12½											291	303	314	325	335	346	355	365	375	384	392	401	410	418	426	434	438
13											307	319	331	342	354	365	375	386	396	406	415	424	434	442	451	460	464
13½											322	336	349	361	373	384	396	407	417	427	438	448	457	466	476	485	490
14											338	353	366	379	392	404	416	428	439	450	460	471	481	491	501	511	516
14½											355	369	384	398	411	424	436	449	461	472	484	495	506	516	527	537	542
15											371	386	401	416	430	444	457	470	483	495	507	519	530	541	552	563	569
15½														435	450	464	478	492	505	518	531	543	555	567	579	590	595
16														454	469	485	499	514	528	542	555	568	580	593	605	617	623
16½														473	489	506	521	536	550	565	579	592	606	619	632	644	650
17														492	509	526	542	558	573	588	603	618	632	642	659	672	678
17½																546	564	580	596	612	628	643	657	672	686	699	706
18																567	585	603	620	636	652	668	683	698	713	727	734
18½																588	607	625	643	660	677	694	709	725	742	756	763
19																609	629	648	667	684	703	719	736	752	769	784	792
19½																	651	671	690	708	727	745	763	780	795	813	821
20																	673	694	714	734	753	771	789	807	825	843	850
20½																	695	716	738	758	778	797	816	835	853	871	880
21																	717	739	760	782	803	824	844	863	882	900	909
21½																				807	829	851	871	891	910	929	939
22																						876	898	919	940	960	969
22½																						903	925	948	969	989	999
23																						930	954	976	997	1019	1030
23½																							981	1004	1027	1049	1060
24																							1008	1033	1056	1079	1091
24½																							1037	1061	1085	1109	1121
25																							1064	1090	1115	1139	1152
25½																										1170	1183
26																										1201	1214
26½																										1232	1245
27																										1263	1276
27½																											
28																											
28½																											
29																											
29½																											
30																											
30½																											
31																											
31½																											
32																											

VALUE OF d, OR DISTANCE SUPPORTED BY FLANGE OF HEAD

Thickness of Head, In.	Working Pressure, Pounds Per Square Inch													
	50	60	70	80	90	100	110	120	130	140	150	160	170	180
	Distance Supported by Flange, Inches													
7/16	3.00	3.00	3.00	3.00	3.00	3.00	2.86	2.75	2.63	2.53	2.45	2.37	2.30	2.23
1/2	3.50	3.50	3.50	3.50	3.50	3.50	3.33	3.21	3.07	2.95	2.85	2.77	2.68	2.60
9/16	4.00	4.00	4.00	4.00	4.00	4.00	3.81	3.66	3.50	3.38	3.26	3.16	3.06	2.98
5/8	4.50	4.50	4.50	4.50	4.50	4.50	4.29	4.12	3.95	3.80	3.67	3.56	3.44	3.35
11/16	5.00	5.00	5.00	5.00	5.00	5.00	4.77	4.58	4.38	4.22	4.08	3.95	3.83	3.72
3/4	5.50	5.50	5.50	5.50	5.50	5.50	5.24	5.04	4.82	4.64	4.49	4.35	4.22	4.10
13/16	6.00	6.00	6.00	6.00	6.00	6.00	5.72	5.50	5.26	5.07	4.90	4.74	4.60	4.47
7/8	6.50	6.50	6.50	6.50	6.50	6.50	6.20	5.96	5.70	5.49	5.31	5.14	4.98	4.84
15/16	7.00	7.00	7.00	7.00	7.00	7.00	6.67	6.42	6.14	5.91	5.71	5.53	5.37	5.21
1	7.50	7.50	7.50	7.50	7.50	7.50	7.15	6.88	6.57	6.33	6.12	5.93	5.75	5.59
1.0	8.00	8.00	8.00	8.00	8.00	8.00	7.63	7.33	7.00	6.76	6.53	6.32	6.13	5.96

be used in any particular case may be the larger of the following values, which are quoted directly from Par. 214 of the Boiler Code:

(1) d = Outer radius of flange, not exceeding eight times the thickness of the head.

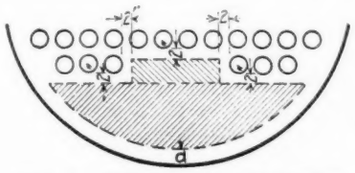


FIG. 2. IRREGULAR SEGMENT BELOW TUBES

(2) $$d = \frac{5 \times T}{\sqrt{P}}$$

in which

d = Unstayed distance from shell, in inches;

T = Thickness of head, in sixteenths of an inch;

P = Maximum allowable working pressure, in pounds per square inch.

After the value of d has been found for a particular case, it is subtracted from the radius of the boiler, giving $(R - d)$, which is the radius of the curved edge of the segment whose area is to be found. The height of this segment is the distance from the tubes to the shell less the distance d supported by the flange and the 2 in. supported by the tubes, or $(H - d - 2)$. These two quantities having been found, the area of the segment in square inches may be calculated by using the formula,

$$Area = \frac{4(H - d - 2)^2}{3} \sqrt{\frac{2(R - d)}{(H - d - 2)}} - 0.608$$

To do away with calculations of d, the two small tables are given. The first was prepared by F. R. Burlingame and covers the values of d for all pressures from 50 to

BOILER HEADS TO BE BRACED

$(R - d)$, in Inches

32	32½	33	33½	34	34½	35	35½	36	36½	37	37½	38	38½	39	39½	40	40½	41	41½	42	42½	43	43½	44	44½	45	$(H-d-2)$ Inches
																										3
																										3½
																										4
																										4½
																										5
																										5½
																										6
																										6½
																										7
																										7½
																										8
																										8½
																										9
																										9½
321																										10
344																										10½
371																										11
392	395																									11½
417	421																									12
442	446	450	454																							12½
468	472	476	480																							13
494	498	503	507																							13½
520	525	529	534																							14
547	552	556	561	566	571																					14½
574	579	583	589	594	599																					15
601	606	612	618	623	628	633																				15½
629	634	640	645	651	657	662																				16
656	662	668	674	680	686	692	698	704																		16½
685	691	697	704	710	716	722	728	734																		17
713	719	726	733	739	746	752	758	764	770	776	782	788	794	800	806	812	818	824	830	836	841	846	851	856	861	866	17½
742	749	756	763	769	776	782	789	796	802	808	815	822	829	835	841	847	853	859	865	871	877	883	889	894	899	904	18
770	778	785	792	799	806	813	820	827	833	840	847	854	861	868	875	882	889	895	901	907	913	919	925	931	937	942	18½
799	807	815	822	829	837	844	851	858	865	872	879	886	893	900	907	914	921	928	935	942	949	956	962	968	974	980	19
829	837	845	852	860	868	876	883	890	898	905	912	919	927	934	941	948	955	962	969	976	983	990	997	1004	1011	1018	19½
859	867	875	883	891	899	907	915	923	930	938	946	953	961	969	977	985	992	999	1006	1013	1020	1027	1034	1041	1048	1054	20
888	897	905	914	922	930	938	947	955	963	971	978	986	994	1002	1010	1018	1026	1034	1041	1048	1055	1062	1069	1076	1083	1090	20½
918	927	936	945	953	962	970	979	988	995	1004	1012	1020	1029	1037	1045	1053	1061	1069	1077	1084	1091	1098	1105	1112	1119	1126	21
949	957	966	976	985	994	1003	1011	1020	1029	1037	1046	1054	1063	1072	1081	1089	1097	1105	1113	1121	1129	1136	1143	1150	1157	1164	21½
979	988	997	1007	1016	1026	1035	1044	1053	1062	1071	1080	1089	1097	1106	1114	1122	1130	1138	1146	1154	1162	1170	1178	1186	1194	1202	22
1009	1019	1029	1039	1048	1058	1068	1077	1087	1096	1105	1114	1123	1132	1141	1150	1159	1168	1176	1184	1192	1200	1208	1216	1224	1232	1240	22½
1040	1050	1061	1071	1080	1090	1100	1110	1120	1130	1139	1148	1158	1167	1176	1185	1194	1203	1212	1220	1229	1238	1247	1255	1263	1271	1279	23
1071	1081	1092	1102	1113	1123	1133	1144	1154	1163	1173	1183	1193	1203	1212	1222	1231	1240	1249	1258	1267	1276	1285	1294	1303	1312	1320	2 ¼
1102	1113	1124	1134	1145	1156	1167	1177	1187	1198	1208	1218	1228	1238	1248	1258	1268	1278	1288	1297	1306	1315	1324	1333	1342	1351	1360	24
1132	1144	1156	1167	1178	1188	1200	1211	1222	1233	1243	1253	1264	1274	1285	1295	1305	1315	1325	1335	1345	1355	1365	1374	1383	1392	1401	24½
1164	1176	1187	1199	1211	1222	1233	1245	1256	1267	1277	1288	1299	1310	1321	1331	1342	1352	1362	1372	1382	1392	1402	1412	1422	1432	1442	25
1196	1208	1220	1232	1244	1255	1267	1278	1290	1302	1313	1324	1335	1346	1357	1368	1379	1389	1399	1410	1421	1432	1442	1452	1462	1472	1482	25½
1226	1239	1252	1265	1276	1289	1301	1313	1325	1337	1348	1360	1371	1383	1394	1405	1416	1427	1439	1450	1461	1472	1483	1493	1503	1513	1523	26
1258	1272	1285	1298	1311	1323	1335	1347	1360	1372	1384	1396	1407	1419	1431	1442	1453	1465	1476	1487	1498	1509	1520	1531	1544	1554	1564	26½
1290	1303	1315	1330	1343	1356	1370	1382	1395	1407	1419	1431	1443	1456	1468	1479	1491	1503	1515	1527	1539	1551	1563	1574	1585	1596	1607	27
			1363	1376	1390	1405	1417	1430	1443	1455	1468	1480	1493	1505	1518	1529	1542	1554	1565	1577	1590	1602	1614	1626	1638	1650	27½
			1397	1410	1424	1439	1452	1465	1478	1491	1504	1517	1529	1542	1555	1567	1580	1592	1604	1616	1628	1640	1652	1664	1676	1687	28
			1430	1445	1459	1473	1486	1501	1513	1527	1540	1554	1567	1580	1593	1606	1618	1631	1644	1657	1669	1681	1694	1707	1720	1733	28½
			1462	1477	1493	1507	1521	1535	1549	1564	1578	1591	1605	1618	1632	1645	1658	1671	1684	1697	1710	1722	1735	1748	1761	1774	29
									1585	1599	1613	1628	1642	1656	1670	1682	1696	1710	1723	1737	1750	1763	1777	1790	1803	1816	29½
									1620	1635	1650	1666	1680	1694	1708	1722	1736	1750	1763	1776	1789	1804	1817	1830	1843	1856	30
															1748	1760	1775	1789	1803	1817	1831	1844	1858	1872	1886	1900	30½
															1788	1800	1814	1828	1843	1858	1872	1886	1900	1914	1928	1941	31
																					1913	1928	1942	1957	1969	1985	31½
																					1955	1969	1984	1997	2011	2028	32

Stayed, in Square Inches

VALUE OF d, OR DISTANCE SUPPORTED BY FLANGE OF HEAD

Working Pressure, Pounds per Square Inch

Thickness of Head, In.	190	200	210	220	230	240	250	260	270	280	290	300	310	320
	Distance Supported by Flange, Inches													
1/4	2.17	2.12	2.07	2.02	1.98	1.94	1.90	1.86	1.83	1.79	1.76	1.73	1.70	1.68
5/16	2.54	2.47	2.41	2.36	2.31	2.26	2.21	2.17	2.13	2.09	2.05	2.02	1.99	1.96
3/8	2.90	2.83	2.76	2.69	2.64	2.58	2.53	2.48	2.43	2.39	2.35	2.31	2.27	2.24
7/16	3.26	3.18	3.11	3.03	2.97	2.90	2.85	2.79	2.74	2.69	2.64	2.60	2.56	2.52
1/2	3.63	3.54	3.45	3.37	3.29	3.23	3.16	3.10	3.04	2.98	2.94	2.89	2.84	2.79
9/16	3.99	3.89	3.80	3.71	3.63	3.55	3.48	3.41	3.35	3.29	3.23	3.17	3.12	3.07
5/8	4.35	4.24	4.14	4.04	3.95	3.87	3.79	3.72	3.65	3.58	3.52	3.46	3.41	3.35
11/16	4.72	4.59	4.49	4.38	4.29	4.20	4.11	4.03	3.96	3.88	3.82	3.75	3.69	3.63
3/4	5.08	4.95	4.83	4.71	4.61	4.52	4.43	4.34	4.26	4.18	4.11	4.04	3.98	3.91
13/16	5.44	5.30	5.17	5.06	4.95	4.84	4.74	4.65	4.56	4.48	4.40	4.33	4.26	4.19
1.0	5.80	5.66	5.52	5.40	5.27	5.16	5.06	4.96	4.87	4.78	4.70	4.62	4.54	4.47

180 lb. per sq.in. The second small table gives values of d for pressures from 180 to 320 lb. per square inch.

The main table gives the areas of segments to be braced and is based on values of $(R - d)$ and $(H - d - 2)$ differing by half-inches except for values of $(R - d)$ below 31 in.

Suppose that a boiler 54 in. in diameter has a head ½ in. thick and is to carry a working pressure of 180 lb., and that the distance from the top of the tubes to the shell is 22 in. Let it be required to find the area of the segment to be braced.

According to the small table at the left, the value of d for a head ½ in. thick and a working pressure of 180 lb. is 2.98 in., which, for all practical purposes, may be taken as 3 in.

The radius of the boiler is $R = 27$ in. and $H = 22$ in. Therefore, $(R - d) = 27 - 3 = 24$ in. and $(H - d - 2) = 22 - 3 - 2 = 17$ in. In the main table locate 17 in the first column at the left and follow along the horizontal line to the column headed 24. At this point the value 573 appears, which indicates that the area of segment to be stayed is 573 square inches.

The Electrical Study Course—Putting Balancer Sets into Service on Three-Wire System

Deals with the speed regulation of balancer sets composed of compound machines, and with the factors affecting the size of machines to use. Also takes up the subject of starting sets preparatory to connecting load to them.

THE previous lesson brought us as far as a consideration of the elements that affect the speed regulation of a balancer set that consists of compound machines. The connections for such a set are shown in Fig. 1. The series fields H_1 and H_2 are connected in the manner which will cause the machines G_1 and G_2 to operate as differentially compounded

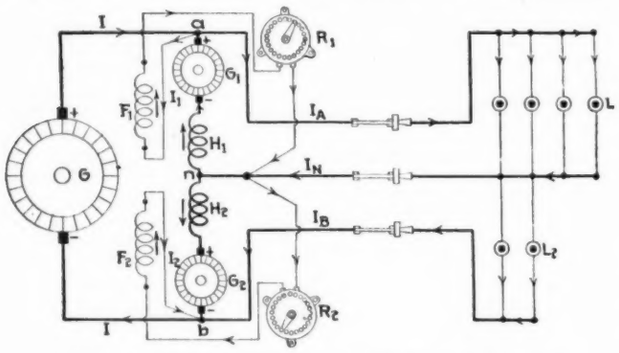


FIG. 1. CONNECTIONS FOR COMPOUND-WOUND BALANCER SET

motors. That is, when running as motors the direction of the current through the series field is such that the magnetization produced by it is in the opposite direction to that produced by the shunt field.

It is to be noted that when connected as in Fig. 1 machine G_1 or G_2 will be a cumulatively compounded one when it runs as a generator. That is, when operating as a generator the magnetization due to the series-field current is in the same direction as that due to the shunt-field current. This is because the direction of the current in the armature, and consequently in the series field, reverses whenever the machine changes from motor to generator or vice versa, while the shunt-field current is always in the same direction. Consequently, we have a differentially compounded motor driving a cumulatively compounded generator, the two being connected in series across the generator G.

Making the same supposition in regard to the load as in the previous lesson—namely, that L_1 is larger than L_2—we know that G_2 must be the motor driving G_1 as the generator. Since G_2 is a differentially compounded motor, its speed will tend to increase as the load upon it is increased, since the effect of the load current through the series field is to reduce the excitation. However, as soon as it begins to increase in speed it drives G_1 faster, which increases the voltage of G_1, causing it to furnish a greater current and thereby increasing its voltage still more owing to the cumulative effect of the current through the series field. As the voltage across G_1 increases, that across G_2 must decrease, since it is the difference between the constant voltage maintained across *ab* by G and that across *an*.

Decreasing the voltage impressed upon a motor causes its speed to be reduced, consequently the accelerating action of the current in the series field is checked by the drop in voltage. The difference between this method and the one using shunt machines with interchanged fields, described in the last lesson, is that in this method the accelerating action is due to the increase of load on G_2, and the retarding action is due to the increase of voltage across G_1, whereas in the other method acceleration is due to decrease in voltage across G_1, and the retarding effect is due to the increase of load on G_2.

The size of the machines used in a balancer set depends upon the maximum value that it is expected the unbalanced load current will reach. If it is known that the amount of unbalancing will never be very great, small machines may be used for the service irrespective of what the total load on the system might be. On the other hand, if the unbalancing is likely to be very large, the capacity of the balancer machines must be greater. That is, there is no direct relation between the total load a three-wire system is called upon to take care of and the size of the balancer set that must be provided. Thus, a comparatively large system on which only a slight unbalancing could occur at any time would require a much smaller balancer set than a smaller system on which serious unbalancing had to be provided for.

The extreme case of unbalancing would be that in which all the lamps on one side or the other might be turned out. In such a case each balancer machine would have to be big enough to take care of half the

full current of one side of the system, since under those conditions the current in the neutral would be the same as in the loaded outside wire, and, as shown in the previous lesson, the current in the neutral wire divides nearly equally between the two machines.

Balancer sets may run continuously for long periods of time, but there are of course occasions when they must be shut down, and means must therefore be provided for starting them up again when they are to be placed in service. We shall therefore give some consideration to the methods used.

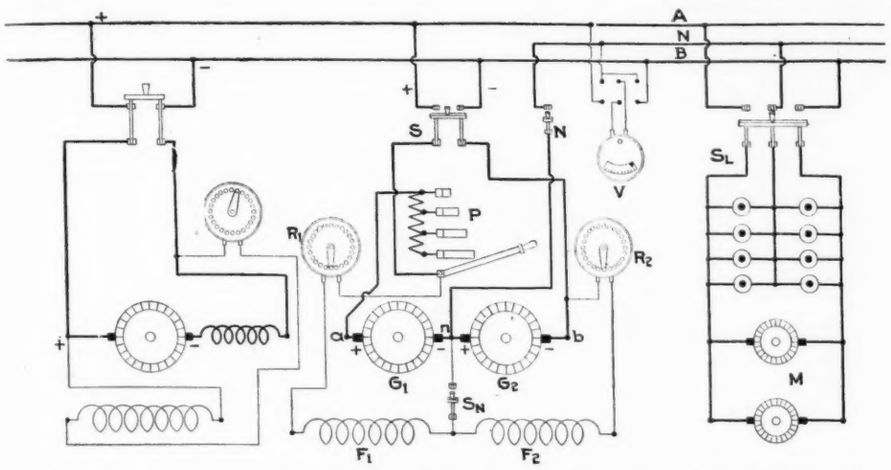


FIG. 2. SWITCHING SCHEME FOR BALANCER SET ON THREE-WIRE SYSTEM

Fig. 2 represents a simple arrangement. For the sake of clearness the machines G_1 and G_2 are shown of the shunt type and their fields F_1 and F_2 are shown each connected to its own machine instead of being interchanged. As shown, the two machines are connected in series to the starting switch P. The resistance of the field rheostats R_1 and R_2 is all cut out, and the switch S_N is opened, thus placing the field windings F_1 and F_2 in series without any connection to the neutral. It is necessary to do this for the reason that, for the polarity shown, the armature of G_2 when at rest would act as a short-circuit across its field F_2, causing the voltage across F_1 to be very small at the moment of starting and consequently impressing double normal voltage across F_1 and causing it to take twice normal current while practically no current flowed through F_2. By opening switch S_N the same current is made to flow through both F_1 and F_2, thus causing the excitation of the machines to be the same.

Besides adjusting R_1 and R_2 to zero and opening S_N, an inspection is made of switch S_L, to see that it is open. Switch S is then closed and the motors are started in the usual manner by means of the starting-switch P, at which time switch S_N is closed. The next step is to close the neutral switch N; then the voltages across G_1 and G_2 are tested by applying voltmeter V across AN and NB. If the machines are not found to have the same voltage, the excitation of the one showing the higher voltage is reduced by increasing the resistance in its field circuit. Thus, if the voltage of G_1 were found to be higher than that of G_2 the resistance of R_1 would be increased in order to reduce the current through F_1 and thus reduce the voltage of G_1, until the voltages across the two machines were the same. They would then be ready to have the load placed upon them, which would be done by closing switch S_L.

The connections for compound machines would be the same as those for shunt ones excepting that the series field would of course be connected as part of the armature circuit. The problem of the preceding lesson consisted of finding the values of the currents in the different parts of a three-wire system such as that in Fig. 1. The load consists of 100-watt and 110-volt lamps of which there are 800 in load L_1 and 600 in load L_2, and the generator G maintains 220 volts across ab. When running idle, the machines G_1 and G_2 draw 20 amperes. Since there are 800 lamps in L_1 each of which consumes 100 watts, the load on this side of the system is $800 \times 100 = 80{,}000$ watts. The voltage across each side being 110 volts, the current required for this load is $\frac{80{,}000}{110} = 727$ amperes. Similarly, the load L_2 is equal to $600 \times 100 = 60{,}000$, and the current required by it is $\frac{60{,}000}{110} = 545$ amperes. The total load on G is the sum of the lamp loads plus the balancer load. The latter is 20 amperes at 220 volts, or $20 \times 220 = 4400$ watts. The load on G is therefore $80{,}000 + 60{,}000 + 4400 = 144{,}400$ watts and this divided by its voltage, namely, 220 volts, will give the current I in the mains, or $I = \frac{144{,}400}{220} = 656$ amperes. From the preceding calculations we have $I_A = 727$ amperes and $I_B = 545$ amperes, from which $I_N = I_A - I_B = 727 - 545 = 182$ amperes. Since I_A is 727 amperes and I is only 656 amperes, I_1 must be equal to $727 - 656 = 71$ amperes in the direction from n to a; and since I_B is only 545 amperes, the current I_2 must be equal to $I - I_B = 656 - 545 = 111$ amperes in the direction from n to b.

In Fig. 3 loads L_1 and L_2 are composed of lamps

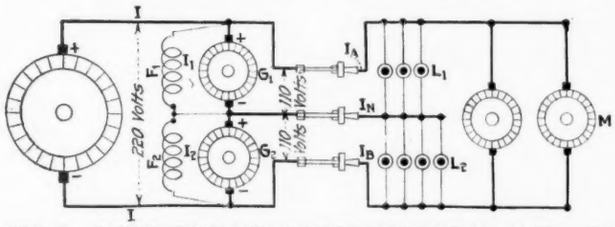


FIG. 3. CONNECTION FOR SHUNT-WOUND BALANCER SET

taking 120 amperes and 180 amperes respectively, and the load M consists of motors taking an aggregate of 230 amperes. The machines G_1 and G_2 take 10 amperes. What are the values and directions of currents I, I_A, I_B, I_N, I_1, and I_2? What would have to be the capacity of the machines G_1 and G_2 to take care of a completely unbalanced condition, if the system is operating at 110 to 220 volts, and the maximum lamp load across each side is 200 amperes?

Chart for Finding the Factor of Evaporation

By G. H. SHEASLEY

IN CALCULATING steam-boiler performance it is necessary to find the factor of evaporation. To do away with computations it is desirable to use some sort of table or chart from which the required factor may be read direct for any given set of conditions. A chart for finding the factor of evaporation is shown in the illustration, and in preparing it an effort has been made to have it cover practically the entire range of conditions that are liable to be met with in practice. The chart shown can be used for either saturated or superheated steam. The factors shown are based on the values given in the steam tables of Marks and Davis.

The method of using the chart may best be illustrated by a couple of examples. Suppose that the factor of evaporation is to be found for the changing of water at 160 deg. F. into saturated steam at a pressure of 140 lb. gage, which is 155 lb. absolute. Locate the pressure of 155 lb. on the bottom scale and proceed vertically until the saturation curve is reached. Next, from this point on the saturation curve follow a horizontal line until the diagonal marked 160 deg. F. is reached. Then proceed vertically to the top of the chart, and the point thus located will correspond to 1.099, which is the factor of evaporation for the conditions assumed.

Next, suppose that the feed water has a temperature of 208 deg. F. and the steam has a pressure of 200 lb. gage and a superheat of 150 deg. F. A pressure of 200 lb. gage is about 215 lb. absolute. So, locate 215 lb. on the bottom scale of the diagram and follow it vertically to the curve marked 150 deg. F. Then proceed horizontally to the diagonal marked 210 deg. F., which is the nearest value to 208 deg. F. From this point on the diagonal, proceed vertically to the scale at the top, where the reading will be found to be 1.141, which is the factor of evaporation.

The total heat per pound of steam of any given condition may also be found from the chart. After finding the intersection of the vertical line from the value of the pressure and the curve representing saturation or degree of superheat, follow horizontally to the scale at the left of the chart, where the total heat will be indicated.

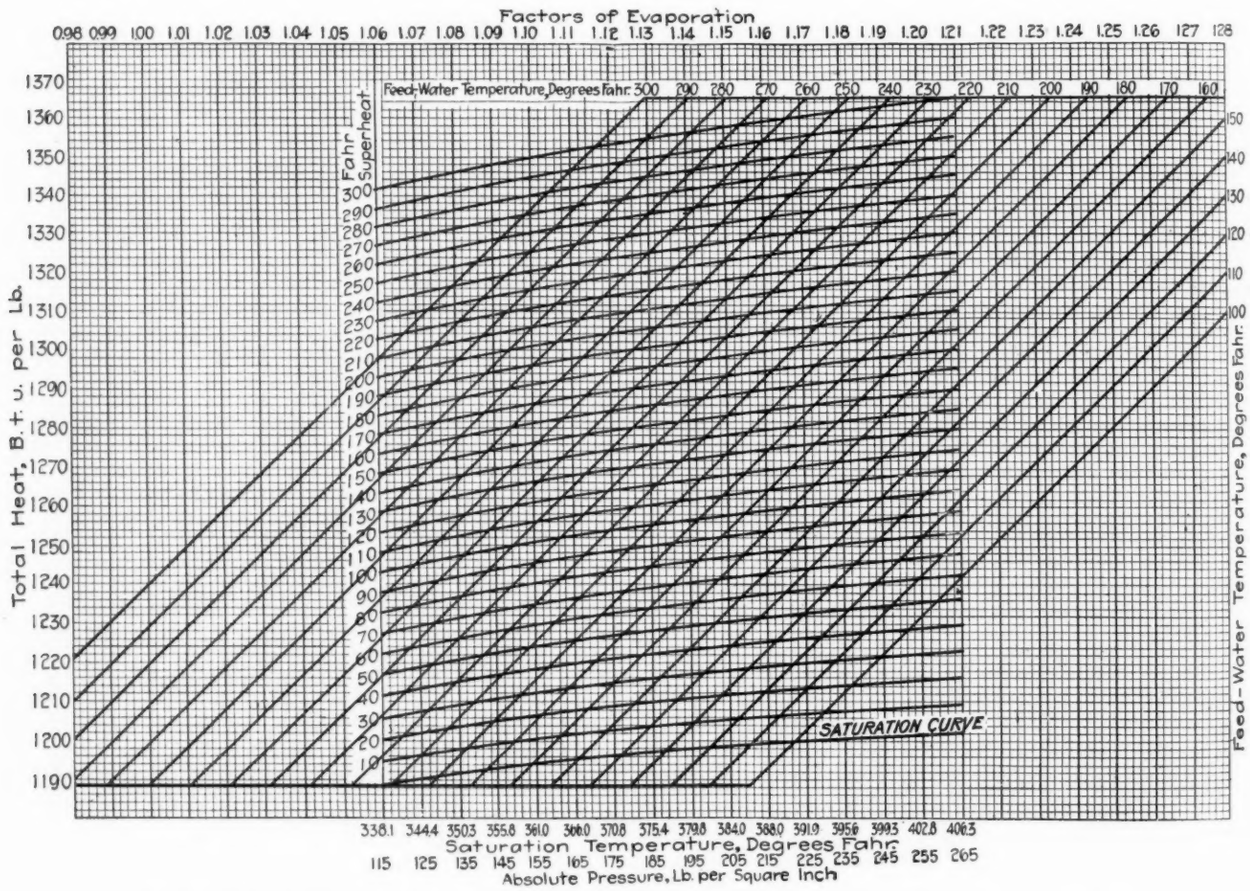


CHART FOR FINDING FACTOR OF EVAPORATION OF SATURATED OR SUPERHEATED STEAM

Charts for this purpose have been made from time to time, some being in the form of alignment charts while others employ a sliding scale. No special advantage is claimed for the chart over any other for the purpose, except that it is so designed as to cover a wide range of conditions and at the same time allow the size of the chart to be reduced to the minimum. Also, all scales are within the limits of the chart and so the use of a straight-edge is unnecessary in the reading of the desired result. Neither is a specially constructed base necessary, as in a chart employing one or more sliding scales.

EDITORIALS

Improving the Qualities of American Marine Engineers

PERHAPS no one more profoundly appreciates the value of the training of marine engineers by the United States Shipping Board's schools than the older engineers who, at first, were demonstrably reluctant to approve the Board's plan for training men for American ships. Marine engineers, from the designers down to the third assistants, are notoriously conservative and tenaciously enmeshed in tradition. Many of the older operating men have not bothered with books or with keeping pace with the advancements in the art. With them, as things were done long ago they should be done today. Naturally, men of this character are inclined to resent the intrusion of the younger men, who were desirably technical if lacking the long years of experience of the older fellows.

A peculiar thing has happened. To shut out the younger or newer type of men for engineer officers of the merchant marine, the staid, conservative engineers, honestly believing they were protecting the service, attempted to "stiffen" the requirements of the United States Steamboat Inspection Service. With the intensive and comprehensive training given applicants by most of the schools of the Shipping Board, they are so well grounded in fundamentals that they quite easily go over paths on which the older, less technical men stumble. Experience is showing that stationary engineers, who have been forced by license legislation and encouraged by their trade organizations to study, make more rapid progress through the Board's schools than do the older type of marine men. But the latter are about to improve, they are agreeably coöperative, and the Shipping Board will doubtless give them every opportunity to meet the new conditions. The merchant marine of Great Britain does not suffer from this trouble as much as the American marine suffers, for the reason that there have long been well-conducted schools in England and Scotland which have been doing for the British seaman what the schools of the Shipping Board are doing for Americans. The service will be immeasurably improved, and every man in it will rejoice at the change. The service is being done as much for them as for the country that is dear to them.

The Skilled-Labor Outlook

POWER plants have been among the most acute sufferers from the labor conditions disjointed by the war. The traveler who observes and listens as he goes not infrequently hears bitter denunciation of the Administration's pre-war policies as the cause of the trying troubles through which those requiring labor have passed and still are passing.

The informed and honest mind will grant that there is a modicum of truth in the argument, but it is only a modicum of truth. The plain fact is that the nations, not alone armies, cannot turn belligerent and preserve the established routine of peace. Increased remuneration, within reason, is the incentive which promotes productive rate. War is precipitate and requires of a nation accelerated production, and it requires it forthwith. Labor would have had to be stimulated in 1914 or 1916 just as it was stimulated later when America awoke to her duty. The exigencies of the moment caused the unparalleled labor turnover, and by the same immutable social law it will force another turnover now that the crisis has ended overnight.

Extraordinarily high wages were for labor part of the spoils of war. Their continuation far into the period of adjustment or of peace would impose a ruinous burden. Their too sudden reduction would create a perilous psychological situation full of the virus of Bolshevism. And the peril of Bolshevism is real, even for America.

As regards the skilled-labor outlook engaged in power-plant work, a resumption to normal is making pleasing headway. The desirable labor is returning, less cocky than when it went away. The lure of other places has lost its punch, and the good men, once back on the old job, are content to stay. We find the plants of the country still in abnormal condition, but rapidly coming back to the stability of the days that seem so long ago.

The New Laboratories of the Bureau of Mines

THE Bureau of Mines is one of the noteworthy achievements in the progress of the relationship between technology and the Government. It is, however, peculiar that the Bureau is legally but a Government servant; that is, it is legally an advisory and technical bureau for use only by Government departments. Legally, it is not for the service of industry broadly. But Government departments require so much industrial information that no infractions of the law are made by the Bureau when it takes up the varied work which it performs and which is invaluable to the industries. We understand that this is not true of the Bureau of Standards; it is not so restricted.

But someone needs to enlarge the vision of Congress to the end that such a far-reaching technical branch of the Government as the Bureau of Mines may spread out to fields adjacent to those in which now it makes two blades of grass grow where but one grew before. Appropriations for the Bureau are woefully small. Programs laid out by the mechanical, chemical and mining divisions must be done with much the same niggardly caution with which the clerk, professional or other of the intermediate millions now buys a pair of shoes. Frugality is a virtue which the Bureau exercises. Some day the industries which benefit in such great measure from the work of the Bureau may give the substantial support that they should be called upon to give.

Elsewhere in this issue the new laboratories of the Bureau of Mines are described and profusely illustrated. From the article one will see that these laboratories are a great workshop. They are substantial evidence of the widening scope of the Bureau, in which the people of the country have an investment that perhaps pays higher dividends than are realized from any other equivalent appropriation.

The Passing of the Use of Carbon-Filament Lamps

WAR has left its effects, both beneficial and otherwise, upon every industry. In the field of illumination one of the most marked effects was a reduction of fifty per cent. in the sale of carbon-filament lamps during 1918 from that in 1917. This type of lamp has long since outlived its economical existence, therefore it must give way to the more efficient tungsten-filament type. When it is considered that the fifty-watt tungsten lamp will give three times as much illumination as the fifty-watt carbon lamp, and that the cost of the former is only about fifty per cent. greater than that of the latter, and that for the last five or six years one type has been just about as durable as the other, it is difficult to understand how a market could be found for twenty-four million carbon-filament lamps in this country in 1917.

When the tungsten lamp was introduced in 1907, its high efficiency soon made it apparent that with improvements in the filament to make it more substantial, this type of lamp was going to replace the carbon-filament type in a few years. However, the carbon lamp held its own until about 1914, when the sales dropped from approximately fifty-five to twenty-five millions. The supplying of these uneconomical lamps free to their customers by many of the central-station companies has doubtless had a marked effect in maintaining millions of them in use. As late as 1917 there were some seventy cities in the United States having a population of forty thousand each and over, aggregating a total of approximately eight million, five hundred thousand, where central-station companies were supplying carbon lamps free to their customers. This figure does not include those cases where carbon-filament lamps are supplied free and tungsten lamps sold at a reduced rate. How long this might be continued under normal conditions is hard to surmise, but under the stress of the abnormal conditions brought about by the war many of the central stations abandoned their free-renewal lamp service, and during 1918 a program for the elimination of all unnecessary types of carbon lamps was approved by the United States Fuel Administration. As a result the carbon-lamp sales dropped to less than twelve millions last year, with good prospects that this lamp will pass into disuse in the near future.

The cost of keeping twenty-four million carbon-filament lamps in service per year over the same number of tungsten lamps of equal candlepower is difficult to determine, but it has been estimated that it means the burning of over one million additional tons of coal, not to mention the loss in human productive capacity due to the poor quality of the illumination from carbon lamps. Even at this late day we are to be congratulated that such an important step has been taken to eliminate this unnecessary waste.

Labor and Mechanical Refinements in Power Stations

POWER-STATION economies have now but one chief road to lower production costs—namely, refinements. The quest for new types of prime movers ended with the steam turbine. Lower costs must now be sought by the more intense and scientific application of established operating principles and by broadening the field of utilization to build up the load factor. Both these entail much.

The production of modern power-station machinery demands a higher class of shop labor than in days gone by. The disjointed labor conditions caused by the war and the troubles experienced with the product of such labor as was available is sorry evidence of this truth. But it is in the power house where lies the greatest gap between mechanical progress and competent operative skill. The one has not, broadly, kept pace with the other. Increasing the load factor means greater continuity of service, a greater unit-time output for the station and its parts. Apart from complications in machinery, closer running clearances, high rates of heat transfer, higher pressures, temperatures and velocities, the load factor alone, as a time element, calls for constant vigilance and, when coupled with the foregoing factors, demands of the operating and maintenance crews a different appreciation of their responsibility, a higher accuracy of judgment, a more thoroughly technical training than necessary to successful operation some years ago.

The state of affairs is appreciated by those in responsible charge, as is evidenced by the educational courses of the National Electric Light Association, the very encouraging technical trend in the national and state conventions of the National Association of Stationary Engineers, and in other lesser bodies. But there should also be more systematic training of the men within the individual station, a more rapid discovery and more decisive disposition of misfits, a more careful study of the adequacy of remuneration of and progressive opportunities for the exceptionally apt worker—a merit system with meritorious rewards.

There was a time when many flouted the idea that a woman could perform mechanical operations, because, according to tradition, she could not even drive a nail straight. That ancient pleasantry received its deathblow in the same war as did Prussianism.

Many articles are received for publication that would be greatly increased in value if they were accompanied by either photographs or sketches. When sending in letters and articles for publication, do not forget the illustrations.

After July 1 there will probably be plenty of brass rails on the market. Engineers who have had difficulty in obtaining condenser tubes may view the future with hopefulness.

You cannot make an engineer out of a man by giving him an indicator any more than you can make a poet out of one by giving him a fountain pen.

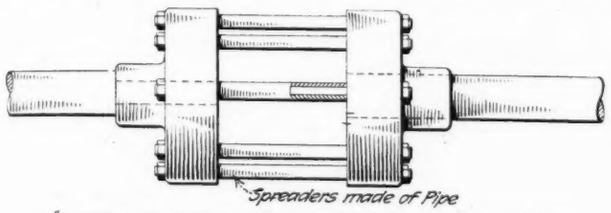
It is fortunate that the cause of world-wide liberty did not turn out as disappointing a failure as the so-called "Liberty" fuel.

Correspondence

Emergency Shaft Repair

Another way in which an emergency shaft repair such as that described in the issue of Jan. 7, page 24, could be made is shown in the illustration herewith.

First procure new coupling bolts longer than the original ones and an equal number of pieces of ¾-in. pipe



HOW SPREADERS WERE APPLIED TO COUPLING

cut to fit and to act as spreaders between the halves of the coupling. If the load on the shaft is heavy, it may be advisable to drill additional holes and use a larger number of bolts than were in the coupling originally.

Schenectady, N. Y. PETER J. M. CLUTE.

Motor Suddenly Reversed

In the Jan. 21 issue of *Power* is given an experience of John R. Steeska where a motor suddenly stopped, reversed and ran in the opposite direction, which brings to mind a similar experience that I had shortly after entering the military service.

In the electrical laboratory at Clemson College, S. C., was a small direct-current generator which was used as an exciter for an alternator. The exciter was rated 250 watts at 110 volts and was compound-wound. One day we connected this machine up as a motor and, as luck would have it, got the series- and shunt-field windings in opposition. The machine would start and run satisfactorily until the starter arm was advanced to the farthest point, when it would slow down, reverse and continue to operate in the opposite direction. This was caused by the inrush of current at starting being sufficient to make the series field stronger than the shunt; the motor then started in a direction corresponding to the polarity of the series-field winding. As the machine came up to speed, the current through the armature and series winding decreased to a point where the shunt field became the stronger and reversed the polarity of the motor, causing it to stop and reverse its direction of rotation.

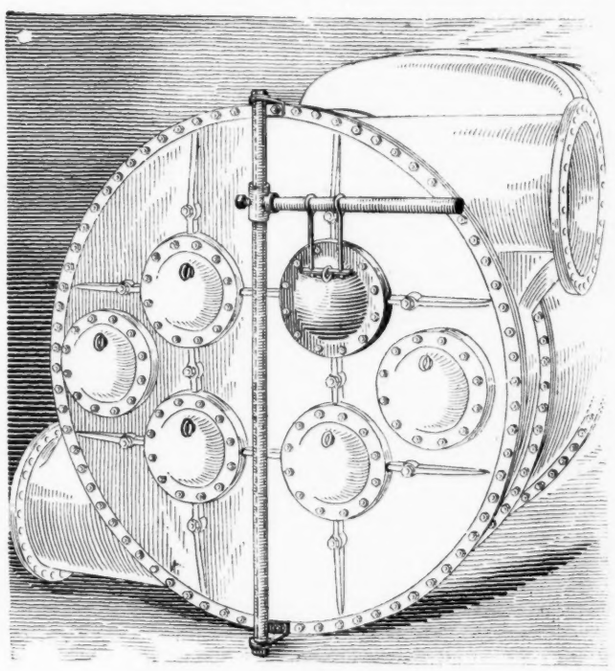
If Mr. Steeska's machine was compound-wound, it may be that it was differentially connected and when a heavy overload of short duration was thrown on, the series field became stronger than the shunt and caused the reversal. R. W. HERRING.

Camp Mills,
Long Island, N. Y.

[When a direct-current compound-wound generator is put into motor service either the shunt-field or series-field windings must be reversed to give the correct polarity to the windings for motor operation. Mr. Herring's experience is that of many others who attempt to operate a compound-wound generator as a motor without reversing one of the field windings.—Editor.]

Crane To Handle Condenser Manhole Plates

It is difficult for one man to remove the manhole plates of a large condenser. The illustration shows an easily made device for this purpose. Two angle brackets are fastened to the condenser shell by drilling through



HOME-MADE MANHOLE PLATE CRANE

and tapping the holes or using bolts. A rod of the proper length is passed through a section of pipe cut long enough to reach from the top to the bottom bracket. A washer and nut are put at the top and at the bottom of the rod and the nuts are tightened, allowing the pipe just enough freedom to swing easily. A tee and a section of pipe, heavy enough to hold the condenser plate, form the arm of the crane. A setscrew in the back of the tee fastens it to the upright pipe at the desired height. Two eye-bolts on the swinging arm and a connecting piece put through the handle in the plate make it possible, after taking the weight on the crane, to remove and swing the plate to one side. Instead of the two eye-bolts a rod with a hook at the end can be used if desired.

Norristown, Penn. WILLIAM H. WATSON.

Unsymmetrical Indicator Diagrams

Again referring to the subject of unsymmetrical indicator diagrams, as answered by Mr. Lewis in the issue of Jan. 28, page 140, taking the diagram as shown and assuming 10 per cent. clearance of piston displacement and $\frac{9}{10}$ or $\frac{8}{10}$ piston travel as points of exhaust closure, I agree with the author that when the exhaust valve closes at $\frac{9}{10}$ stroke the compression pressure at full stroke will be double, and if the exhaust valve closes at $\frac{8}{10}$ stroke the compression pressure at full stroke will be three times as great as the exhaust pressure at the time of exhaust closure, but this is absolute pressure (temperature correction omitted).

Referring to Fig. 1, as that of a high-pressure cylinder and assuming that the absolute zero pressure is 15 lb. below atmospheric pressure and that the back pressure is 20 lb. gage, or 35 lb. absolute, if the exhaust valve closes at $\frac{9}{10}$ stroke with 35 lb. absolute pressure in the cylinder, then the full-stroke compression pressure would be 70 lb. absolute pressure, or 35 lb. effective compression pressure.

If the exhaust closes at $\frac{8}{10}$ stroke, there would be one-third the original volume at full stroke, or three times the original pressure "absolute," but only 70 lb. above the 35-lb. back-pressure line, which is only twice the effective back pressure when the exhaust closure takes place at $\frac{9}{10}$ stroke.

This same condition exists in the low-pressure cylinder, as shown in Fig. 2. Assuming the exhaust pressure

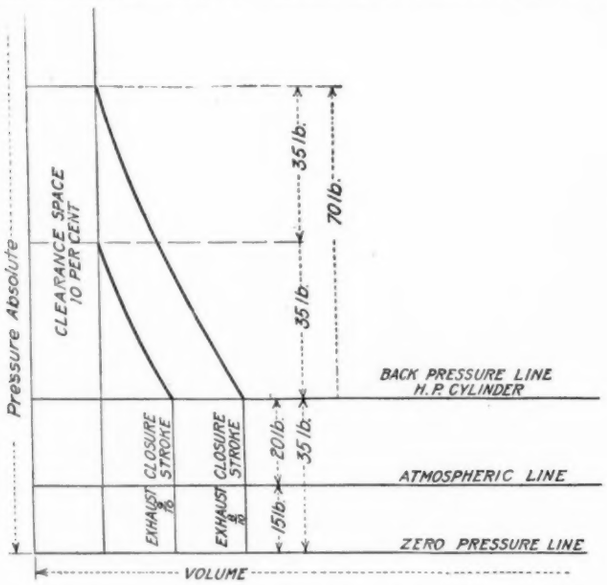


FIG. 1. COMPRESSION CURVES OF HIGH-PRESSURE CYLINDER

to be atmospheric (or any other pressure that it might be), the full-stroke compression pressure with an exhaust closure at $\frac{8}{10}$ will be only twice as great "above the back or exhaust pressure" as when the exhaust closure takes place at $\frac{9}{10}$ stroke.

The nearer the actual indicator diagram approaches the theoretical diagram, or as Mr. Lewis puts it, "a picture in a book," the better will be the economy and the operation of the engine. I recall an instance where an engine attendant loosened the locknuts on the eccentric rod and screwed the rod out until the engine ran noiselessly. After he had caused two perfectly good head-end crosshead pin brasses to cut out and then complained that the brasses were no good, I was called upon to investigate the cause and by indicating the engine found that nearly all the work was being developed in the crank end of the cylinder.

I would like to see the actual indicator diagrams, one set with the compression shifted to one end of

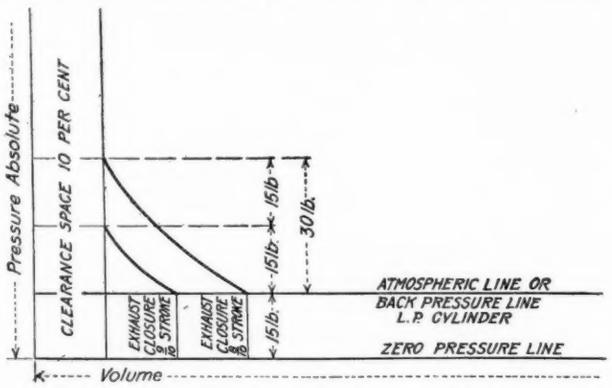


FIG. 2. COMPRESSION CURVES OF LOW-PRESSURE CYLINDER

each cylinder as described by Mr. Lewis, and one set from the same one with the compression equally or nearly equally divided between both ends of each cylinder. I mean by actual cards taken with correct reducing rig. It may be that Mr. Lewis is fooling himself with an incorrect reducing apparatus.

San Francisco, Calif. V. R. HUGHES.

Overheating Hot Water Wasteful

In his letter on page 256 of the Feb. 18 issue Mr. Meinzer says, "There is no economy in drawing a quantity of hot water and then cooling it by the addition of cold water." Neither is there any waste, as there is no loss in mixing cold with hot water to obtain the desired temperature. The hotter the water from the domestic heater the less of it will be used to produce the proper temperature for lavatory purposes, etc., the actual B.t.u.'s used being practically the same per gallon for all ordinary temperatures of the hot-water supply.

The arrangement mentioned of placing steam pipes in kitchen sinks, etc., would hardly be in the interests of economy. A large quantity of steam could be wasted by unskillful handling by the kitchen help, and the steam valves would inevitably leak after having been in use a short time. A steam jet is not an economical water heater, particularly when the temperature of the liquid is near the boiling point, as considerable steam escapes to the atmosphere by being carried to the surface in the form of bubbles.

It is true that by carrying a high temperature in the hot-water mains the heat loss from the pipes is increased to some extent, but this loss would not be serious if the pipes were properly covered.

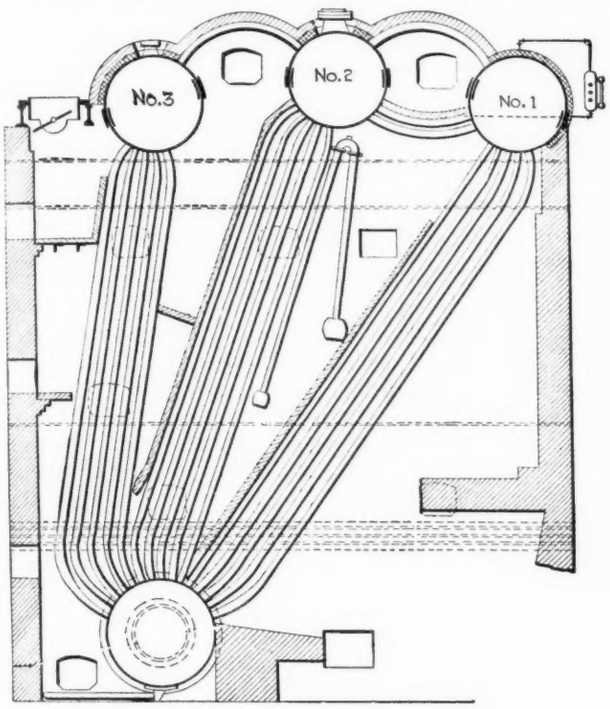
A temperature of 180 deg. at the heater will usually be found to be the most desirable—at any rate where there is a laundry or kitchen. Where water is required for lavatory purposes only, a temperature of about 130 deg. will usually be sufficient. D. F. GRAHAME.

Ottawa, Ont., Canada.

Different Boiler Water Levels

It would have been better if Mr. Regan, in his letter on page 786 in the issue of Nov. 29, 1918, had stated what kind of boilers were in use in the plant to which he referred, how the drums were placed, how the water column was piped and where the baffles were placed between the tubes.

An experience I had with a Stirling boiler a short time ago may clear up some points. The column was



WATER LIFTED IN NO. 1 DRUM

connected up as shown in the illustration, and the location of the fusible plug was at the center of the middle drum and about six inches above the bottom of the drum. The first pass of the gases is up the first bank of tubes under the first drum, then down the second bank and up to the stack. The water circulation is of course from the cooler to the warmer part of the boiler, and in this case it was from No. 3 drum, where the feed water also enters. Steam is drawn for the No. 2 drum.

We start with two inches of water in the glass and a low fire. A hot fire would send the water up in the glass about four inches, and after starting the engine the water would go still higher. If the engine was shut down the water would drop back to the two-inch level and it would sometimes drop out of sight at the noon hour; but on starting up again it would go half way up the glass, sometimes more.

The reason is apparent, for No. 1 drum and bank of tubes receive the hottest gases and do the most work, and, with the rapid circulation, the water is forced into No. 1 drum, producing a higher level than in either of the other two drums. Some may say that taking steam from the middle drum would not cause the water to rise in No. 1 drum; but all the drums are connected at the top, and starting the engine simply takes steam from each as fast as made. It is a question whether there might not have been times when the plug was exposed during the time the engine was in operation. The remedy was to connect the bottom of the water column to the middle drum on a level shown by the dotted lines in No. 1 drum; the water level can then be kept wherever desired. This can be done by connecting into the middle head near the bottom.

I once had a similar boiler piped with the water column connected to the middle drum and the steam to No. 1 drum, and no trouble was experienced, although the boiler supplied a turbine carrying a variable railroad load. When the turbine was shut down, the water level would remain stationary.

I think if Mr. Regan would trace out the path of the water and gas circulation, he would find his case similar to mine. WILLARD E. MORSE.

Orange, Mass.

Abstracting Heat from Blowoff Tanks

Drip and blowoff tanks containing hot water that cannot be utilized, should be equipped with inside coils of pipe through which water on its way to the house hot-water tanks and feed pumps can flow, thus absorbing the heat from these dirty drips and blowoffs, which would otherwise go to the sewer.

Brooklyn, N. Y. W. T. MEINZER.

Burning Fuel Oil in a Coal-Burning Furnace

The picture may interest readers of *Power* as illustrating the results that may occur through the application of oil fuel in a boiler setting that was originally designed to burn coal; that is provided the term "design" is applicable to a setting of this kind.

As a boiler inspector I warned the owner of this boiler some time previously that if oil was used it would be

BAG CAUSED BY BURNING FUEL OIL IN FURNACE DESIGNED FOR BURNING COAL

necessary to change the setting, so that the oil flame would not be driven up by the remains of what was once a bridge-wall. This warning was disregarded with the result shown.

The bag on the boiler is down about 4½ in. and is cracked open at the bottom where the metal is drawn down to a knife-edge thinness. The shell plate is also cracked open at the rivets in the girth seam.

San Francisco, Calif. R. L. HEMINGWAY.

Carbon and Commutator Wear

As mentioned in the letter by R. E. Hellmund in the Feb. 4 issue of *Power*, there is need both among carbon manufacturers and designing engineers of electrical machinery for more definite data on how carbon wear is affected by current density, sparking voltage and peripheral speed. However, the effect of each of these characteristics on brush wear is influenced to such a great extent by other factors that exact determination is practically an impossibility.

Consider the effect of current density. The increased brush wear caused by increase in current density is due to the higher temperature so created at the brush face and the consequent more rapid disintegration of the carbon at that point. Any factor tending to further increase the temperature at the brush face will add to the rapidity of wear. Some of the things having this effect are: High coefficient of friction; higher contact drop than is needed for commutation, especially on machines of low voltage and high current capacity; contact drop too low for sparking voltage, permitting heavy currents to flow in the short-circuited coil; lack of carrying capacity or very high current density.

As mentioned by Mr. Hellmund, higher current densities are permissible where there is no sparking voltage than where there is. This is because the heating effect of commutation current is absent and higher load currents can be applied before the same temperature rise is attained.

Permissible Sparking Voltage

Mr. Hellmund's statement that sparking voltages of 15 to 20 volts are permissible if the current density is low enough is open to question. Average volts per commutator segment may be as high as the figures named without difficulty being encountered. Or the reactance voltage may be that high and still be neutralized by interpole flux or fringing field within sufficiently close limits to secure good commutation. But the sparking voltage—that is, the resultant between the reactance voltage and the other electromotive forces generated within the coil undergoing commutation—should be less than the contact drop of positive plus negative brush to attain perfect commutation. Inasmuch as 3 volts is about the highest brush-contact drop obtainable, it will be seen that the sparking voltages mentioned would not be neutralized within 12 to 17 volts. Such a voltage would set up excessive currents in the short-circuited coils and result in rapid burning away of the brush faces even with no-load current whatever carried by the machine.

Commutator wear may be caused by the use of abrasive brushes. It may also result from the same mechanical or electrical causes that produce brush wear. Mechanical conditions of this nature are: Rough commutator due to poorly prepared surface; rough commutator caused by burning; vibration from any source such as the pound of a direct-connected engine, poor belt lacing, improper mounting, loose bearings or commutator out of true; high peripheral speed, causing brushes to chatter or creating an excessive temperature at the brush faces due to friction; type of brush-holder or angle of operation, resulting in the chattering of the brushes.

Electrical conditions causing rapid brush wear are: Sparking, from any cause whatever; glowing of brushes; pitting of brush faces.

Glowing results from excessive current density and may be local or may cover the entire contact end of the brush. Common causes are unequal collection of current by different brushes of the same polarity and very heavy short-circuit currents in the coils undergoing commutation, which, added to the load current, bring the temperature of the carbon at the face of the brush up to the glowing point.

Pitting may result from glowing in small spots on the brush face. It is also caused at times by particles of copper becoming attached to the brush face. This causes a heavy current to localize in a small area, disintegrating the carbon and forming a small crater in which the copper embeds itself.

Resistance to Disintegration of Brushes

The source of brush wear from all electrical and some mechanical causes is disintegration of the carbon at the brush face due to the temperature attained at that point. There is considerable difference, however, in the ability of different forms of carbon to resist this disintegration. Graphite is much more refractory than amorphous carbon, consequently there is less wear on a graphite brush from a given degree of sparking than will occur with a coke brush. Even better than the brush made up from pure graphite, held together by a carbonized binder, is the electrographitic brush. This type of brush can be made much harder and stronger than the molded graphite brush, thus offering superior resistance to the mechanical causes of wear. In addition, the binding material in the electrographitic brush has been transformed into graphite and possesses high refractory properties, while the binder in a molded graphite brush is merely converted into coke during the baking process and consequently is more susceptible to disintegration under sparking and glowing.

It is unfortunate that it is not possible to accurately determine the influence on brush wear of the factors mentioned by Mr. Hellmund. It is possible, however, to obtain a great deal more data than are now available on certain other brush characteristics which have a pronounced influence on brush wear.

Contact drop should be studied under commutating conditions, since figures obtained on slip-ring tests are of doubtful value when applied to commutating service. Sparking voltage should be determined for each grade of brush under varying conditions of current density and peripheral speed. By sparking voltage is meant the resultant voltage in the coil undergoing commutation below which no visible sparking occurs.

Thermal conductivity should be studied as a guide to the amount of radiation or ventilation that must be provided to keep the temperature at the brush face below an injurious value. Finally, the refractory properties of various grades and the influence on these properties of the brush composition and the method of manufacture should be studied more carefully than has yet been done. By this means grades may be developed which are capable of meeting much higher current densities, sparking voltages and peripheral speeds than any which have been produced up to the present time.

Columbus, Ohio. WARREN C. KALB.

Inquiries of General Interest

Conversion of Pump into Air Compressor—For best results, what changes should be made in a single direct-acting steam pump to convert it into an air compressor? R. W. C.

Ordinarily, the water cylinders of pumps are provided with a liberal percentage of clearance volume, as it is advantageous to their operation and adds convenience in their design and construction. For compressing air efficiently there should be a minimum percentage of cylinder clearance, and conversion of a steam pump into an efficient air compressor would at least require replacement of the water cylinder by a properly designed air cylinder.

Selection of Boiler Capacity—What number of boiler horsepower should be installed for supplying steam to a 500 hp. engine? W. D.

A boiler horsepower is the equivalent evaporation per hour of 34.5 lb. of water from and at 212 deg. F., and the evaporative capacity of a boiler is assumed to be based on good firing, fair quality of fuel and good draft. The number of pounds of steam required for development by an engine of an indicated or an actual horsepower, varies with different types of engines from about 12 lb. to 50 lb. of steam per horsepower per hour according to the type of engine and the actual load. For most situations it is advisable to install at least 25 per cent. larger number of boiler horsepower capacity than the number of engine horsepower that is to be developed, in order to provide against temporary excessive demands for steam, poor grade of fuel and imperfect draft, and to have spare capacity for cleaning fires and for boiler inspection, cleaning and repairs.

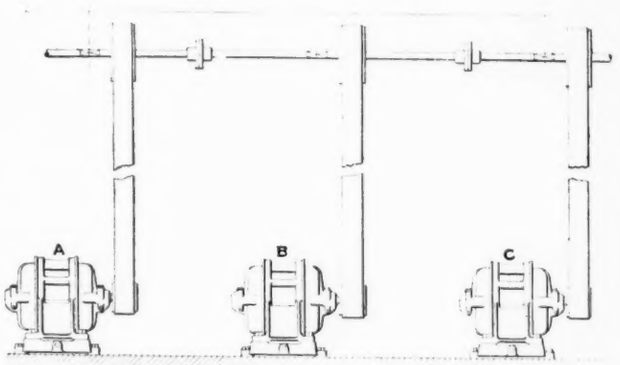
Making Hydrostatic-Pressure Test with Injector—It is desired to make a hydrostatic test of a boiler that is to carry a pressure of 110 lb. per sq.in. What should be the test pressure, and could such a test be made with an injector that is supplied with steam from another boiler carrying a pressure of 110 lb.? J. C.

It is customary to subject boilers to a hydrostatic-test pressure 50 per cent. greater than the proposed working pressure. Most good forms of feed-water injectors, when supplied with dry steam, are capable of forcing the water against pressures at least 50 per cent. greater than the pressure of the steam supply, and injectors are manufactured that obtain much higher test pressures. When an injector is used as a test pump, the safety valve of the boiler under test should be set at less than the test pressure, so the test pressure will not be exceeded. When the safety valve opens and the test gage indicates about 80 per cent. of the intended test pressure, the discharge of water from the safety valve should be gradually throttled, and the injector stopped immediately when the test pressure has been reached.

Unbalanced Load on Induction Motors—We have in our plant three 75-hp. induction motors driving a lineshaft, as shown in the figure. When motor A is carrying the entire friction load, the ammeter reads 47 amperes per terminal; when A and B motors are running, the ammeter on the former shows 42 amperes per phase, and when all three motors are driving the friction load, the ammeter on motor A shows 35 amperes. When all three motors are driving the full load on the lineshaft, motor A takes 135 amperes, motor B 85 amperes and motor C 75 amperes. The motors are operating on a two-phase 30-cycle 425-volt system. I would like to know why motor A takes more load than either of the other two machines and what may be done to balance the load between the different motors. Motor A operates at a higher temperature than motors B or C. G. A. B.

Since motor A is operating at a higher temperature than the others, it is apparent that the characteristics of the three motors are not the same and that motor A is taking more than its share of the load. When motor A is driving the friction load alone, it takes 47 amperes. The small reduction in this current as the other motors are added is due to two causes. As the mechanical load is reduced on an induction motor, its power factor is also reduced, consequently the current will not decrease in proportion to the load reduction; and the other cause for the small reduction of current in motor A is that this motor is taking more than its share of the load.

An arrangement where two or more motors are used to drive the same load cannot be expected to divide the load equally between the different motors, since it is not possible to design and build two machines that possess identically the same characteristics. Even if the machines had the same internal characteristics, the difference in the external conditions would in all probability affect the load division. The latter will be affected by the position of the rotor in the stator bore, which will be changed as the bearing wears; the voltage at the motors' terminals will change slightly with the location of the motors; the size of the pulley and the tension on the belt, if the machine is belt-driven; again, the resistance of the rotor may change



GROUP OF MOTORS BELTED TO LINESHAFT

by some of the connections between the end rings and bars becoming defective; if the motors are wound-rotor machines, the load characteristic of the machine will be affected considerably by the resistance of the brushes on the slip rings, the machine with the highest-resistance brushes taking the least load.

If the machines are of the wound-rotor type, it may be possible to equalize the load between them by putting new brushes on motors B and C, having a lower resistance than the ones now in use, or putting higher-resistance brushes on motor A. In any case the load can be balanced up by slightly increasing the size of the pulleys on motors B and C or decreasing the size of the pulley on motor A, especially if the latter is made of wood or fiber. However, until there is no danger of one of the motors becoming overloaded, there is not any serious reason why the load should be balanced on the machines. On the other hand, if the load is no greater at any time than that given in the problem, there is no reason why, if the load is properly balanced, two of the motors cannot carry it and will then operate at a somewhat improved power factor over that obtained with the three machines.

All current readings should be made with the same instruments, or if different instruments are used on each motor, they should be checked "before and after" taking readings, to make sure that all instruments read alike.

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Fuel Administration and the Utility Plant*

By CHARLES BROSSMANN†

THERE are no restrictions on coal at present. The utility plant can use all it wishes—at the price, if it is agreeable to them. However, with so many utilities during the last year asking for surcharges, we find the main reason is increased operating expenses, with fuel as one of the chief factors, so that it is quite evident that the price of fuel is still of considerable importance. Granting this, some of the things found in utility-plant practice were peculiar. These conditions are not confined to municipally owned plants, but exist in private plants as well, although probably to a lesser degree.

It is of interest to note an encouraging news item from a paper only a short time ago, in which one large company withdrew its plea for a rate increase, stating that it had determined to see if it could overcome some of its excessive expenses through reduction on the price of coal and better operating conditions. This is a gleam of encouragement, and it is to be regretted that this stand was not taken more often, or at least an endeavor made to cut down expenses so that the surcharge asked need not have been so great.

There have been several means of reducing expenses in utility plants. These can be divided into two general classes—one by interconnection of utility and power plants, where in one case the larger plant will usually be more economical of operation and where the interconnection would result in saving fuel or labor or both—the other reducing operating expenses.

Investigating Proposed Interconnection Projects

The mere fact that interconnection of a smaller and a larger plant could be made does not necessarily imply that there would be a saving. A number of such cases have been carefully investigated, and in some instances it has been found possible to save and in others the interconnection would show even a greater fuel consumption.

In investigating a proposed interconnection, the practice was made to get all possible details of operation, and in numerous cases actual tests were conducted on the plants in question, so that the possible fuel saving could be determined. The Fuel Administration was not concerned in the dollars and cents saving—the main object was the conservation of fuel; but with the information determined, it became an easy matter for the plants concerned to find out what the saving in money would be. One thing that stood out very plainly in some plants was the lack of engineering foresight used, and emphasis should be placed on the fearlessness with which some public officials had determined offhand engineering problems that a competent and trained engineer might spend several weeks in investigating and figuring in order to get the best results.

Another conspicuous feature in some cases was the method of operating without records of any kind, without any effort to determine costs and without any knowledge of the results as compared with other plants. In one instance the superintendent of a light plant was not allowed in the power house and could only look after the street equipment. The power house was looked after by one of the public officials, and changes were being made that at that time seemed absolutely unnecessary. At one place the designer was abused for putting in a certain recording device, and yet the device was not operating, although it was of fine standard equipment; no records were kept and the question of rate increase was up at the time. Just think of a plant using anywhere from sixteen to twenty pounds of coal per kilowatt (See Fig. 1) and selling current to the water department for 30 per cent. less than it cost to make it! Here the current was generated by a small generator operated by a slide-valve engine running with a back pressure and then pumping water with a motor and centrifugal pump, while right in the plant stood a compound-pumping engine with which the over-all steam rate for pumping would have been considerably less than with the centrifugal pump. In this plant a saving of 2000 tons of coal a year was possible.

Fig. 1 gives the increased cost per kilowatt-hour in this small plant, showing the rise of 1½-cent coal cost to almost 3¾ cents per kilowatt-hour sold. It also shows that the coal used ranged from 11½ to 17 lb. per kilowatt-hour generated, or 14 to 21 lb. per kilowatt-hour sold. There is no reason why this plant should not have operated at from 12 to 14 lb. per kilowatt-hour which would have been bad enough, and the inefficiency in operation is almost mainly attributable to both management and methods of operation.

What encouragement is there to an operating engineer who is ordered to discontinue keeping records? Is it any wonder that such a plant should be using almost twice as much coal as necessary? On questioning the fireman, he said he had worked there only three days, and I believed him, for I counted 27 shovelfuls of coal going under that boiler at one firing.

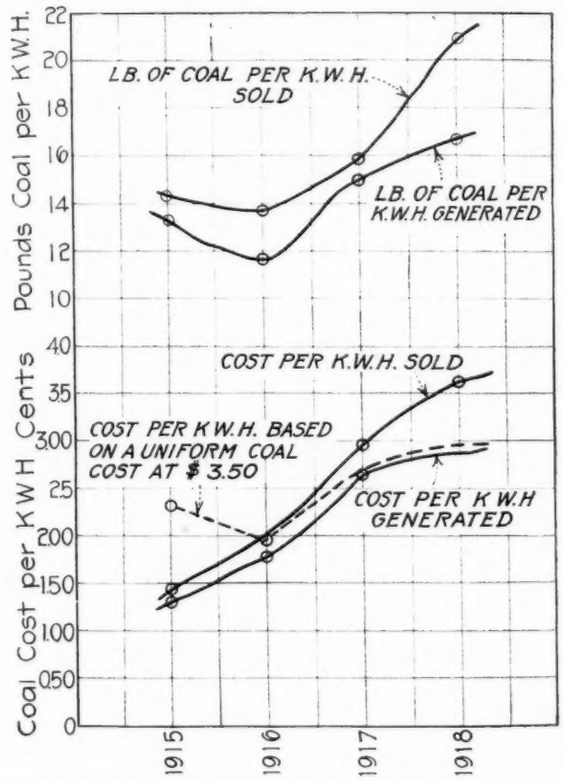
Pounds Coal per K.W.H.
Coal Cost per K.W.H. Cents
LB. OF COAL PER K.W.H. SOLD
LB. OF COAL PER K.W.H. GENERATED
COST PER K.W.H. SOLD
COST PER K.W.H. BASED ON A UNIFORM COAL COST AT $3.50
COST PER K.W.H GENERATED
1915
1916
1917
1918

FIG. 1. SHOWING INCREASED COST PER KILOWATT-HOUR IN SMALL PLANT

In another case careful tests were made on two plants considering interconnection—a municipal light and water plant and a much larger private utility. Loads of both plants were carefully taken and actual coal tests made under several different conditions, and it was found that a saving of almost a thousand tons of coal a year could be made. It is worthy of comment that the superintendent had already cut down his coal consumption on the electric end to a considerable degree. The main reason for this further saving was in the difference of the size and loading of the machines in the two plants, the large plant having almost three times the capacity of the smaller one. In this case the smaller plant was operating at only one-quarter load and was using for this work about six thousand pounds of coal to make the run during the night. A test operated

*Read before the Indiana Engineering Society.

†Consulting engineer, power and utility plants, U. S. Fuel Administration.

on the larger plant, pulling the additional load with its own, showed that only 1000 lb. additional coal was used to do this same work.

Fig. 2 shows the average coal for the station duty run of over 60-hours test with this load. The amount chargeable to running the small-plant street lights is figured as follows:

	Kw.-Hr.	Coal
With street lights	2,920	21,000 lb.
Without street lights	2,040	20,000 lb.
Street lights	880	1,000 lb.

It will thus be seen that to carry the 880 kilowatt-hours for street lights it required 1000 lb. of coal, or 1.12 lb. per kilowatt-hour, which would be the figure to use in comparing with the small plant's coal consumption, in order to show the saving.

It is of interest to note that the average curve for this 60-hour run coincides almost exactly with the load, with or without street lights. This result was due to the fact that the night load was poor and this additional load gave a much better load factor. It should be added, however, that even in this larger plant, no scales were used for weighing coal until the Fuel Administration asked for this test.

In this case the question of electrical pumping was not considered, as no coal saving would have resulted, because the municipal plant was pumping its water with a compound Corliss condensing engine and was using less coal than would have been used by the larger plant to pump electrically.

Electric Pumps Not Always the Most Economical

There seems to be the idea, among a good many central-station men that any electric pump can be operated more economically than any steam pump. This is not always the case. Of course, where labor is saved, that will sometimes even offset what might be lost on coal. In one case where the matter of pumping the water of the municipal plant had been agitated, the proposed interconnecting company had a fair-sized plant, but it was found that to furnish current for pumping, as compared to the city's steam pump, would have resulted in an actual loss of fuel, although it was rather hard to convince the company officials of this fact. This was apparently because they did not realize that a high-duty crank-and-flywheel condensing pumping engine had almost as low a water rate as their large electric unit. However, they were finally, though reluctantly, convinced.

In another instance of interconnection on water plants, it was found and recommended that electrically driven centrifugal pumps, as compared with the old noncondensing duplex, would result in a saving of fuel and labor that would pay for the investment in a little over four years. In this case the city went ahead and made arrangements to change over.

From the foregoing it will be seen that there is only one safe thing to do—investigate each case carefully.

It must not be thought that all the plants examined are horrible examples. Some of the medium-sized plants found in the state were operating at as low as 4½ lb. of coal per kilowatt. In one of these plants the manager has well-kept records of all loads and conditions, and he could give on a moment's notice any information regarding the plant operation. It is rather interesting to know that the most of the plants in which no records are kept and which have no means of determining what is being done are uneconomical. In one particular boiler plant they had the scales, coal cars and water meter, but the fireman only went through the motion of weighing and taking the water records, and put them down so that they looked "about right."

In another instance one operating engineer said he had been "jumped" by the councilman because he did not get the cars of coal off the switch fast enough; they had no place to store it and had to pay demurrage. "The other engineer burned it faster than you do, and I do not see why you can't do it," was the argument.

In one plant, in which the records were fairly well kept, it was found that they were using from 6½ to 7½ lb. of coal per kilowatt-hour generated, and this looked fairly good on the face of it. An analysis of the boiler-flue gases showed only about 4 to 6 per cent. CO_2. It is quite evident that with such a showing there is no reason why the coal per kilowatt-hour should not be further reduced by better boiler economy, and this is being accomplished in this particular plant. Some of the plants visited had the necessary equipment to take the proper tests, but claimed that they were losing money, although they were not trying to better conditions as they should have done.

Analysis of the trouble in many of these plants shows that a large part of their losses is caused by improper boiler-room operation and by not keeping proper records or by not properly analyzing them. There have been many plants where from 10 to 20 and even 50 per cent. saving in coal could be made simply by changes in operating methods. This is one of the important lessons of which advantage should be taken.

Another most important thing is the method in which new equipment is purchased, without any analysis of operating loads and conditions and on the hit-and-miss theory. This trouble comes more from the municipal plants, al-

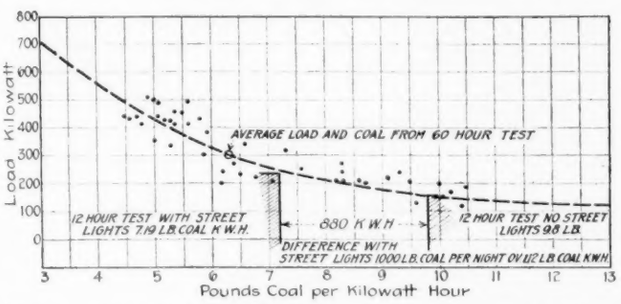
Load Kilowatt
800
700
600
500
400
300
200
100
0
AVERAGE LOAD AND COAL FROM 60 HOUR TEST
12 HOUR TEST WITH STREET LIGHTS 7.19 LB. COAL K.W.H.
880 K.W.H.
12 HOUR TEST NO STREET LIGHTS 9.8 LB.
DIFFERENCE WITH STREET LIGHTS 1000 LB. COAL PER NIGHT OR 1.12 LB. COAL K.W.H.
3 4 5 6 7 8 9 10 11 12 13
Pounds Coal per Kilowatt Hour

FIG. 2. COAL CONSUMPTION WITH HAND-FIRED WATER-TUBE BOILERS: 60-HOUR TEST

though a number of such cases were found in other places. I make the assertion that thousands of dollars are wasted every year in municipalities, by improper purchasing without expert engineering advice and without careful engineering analysis of the true conditions.

The important lessons shown from the Fuel Administration work are:

That too little attention is paid to the proper and economical operation of the plant, as pertaining to the boiler room, as the greater proportion of loss of the plant seems to take place in the manufacture of the steam.

That interconnection in numerous cases would be advisable. Owing to the character of the equipment combined with the methods of operation, economical central stations have power available, and advantage should be taken of the possibility of interconnection so that uneconomical plants can be placed on a sound basis.

Another important reason is found in the method of purchasing new equipment and making additions to plants without any regard to the adaptability of the units purchased. Greater attention should be given to getting the exact working conditions of the plant and to providing economical machinery and purchasing new plant equipment.

I believe that the time has been reached as regards public utility plants or any kind of power plant, when strict attention must be given to proper design and purchase and more accurate methods of operation used; and if such things were looked after there would be much less trouble and fewer failures in such plants.

West Virginia License Bills

A number of bills seeking the same object—the licensing of stationary engineers—were introduced in the West Virginia legislature during the regular session that just ended, but none passed either house. Under the terms of at least one of the bills the owner of a boiler or stationary engine of over 10 hp. could not have operated his own engine, but would have had to hire a duly licensed engineer to run it for him.

Central Station Heating

By JOHN C. WHITE

Abstract of Technical Paper 191, Bureau of Mines, dealing with central-station heating; its economic features with reference to community service. In this abstract it is chiefly costs that are dealt with.

IT IS interesting to note that although many of the early companies charged a rate of only 20c. a sq.ft. (selling steam on the basis of square foot of radiation) for a season of seven or eight months, the fuel cost of energizing such radiation for a period of only six months (180 twenty-four-hour days) with an over-all efficiency of 50 per cent. in generation and transmission, steam at atmospheric pressure and a room temperature of 70 deg. F., would be from 10c. to 15c. with coal at $1 a ton. As few places get their coal at that price, it is easy to see why these heating companies failed. Many electric companies claim a cost of less than 1c. per kw.-hr. at the switchboard; the public, however, except a few large consumers, pays three to ten times that amount for what it uses. Steam heating can never carry such an excess as that, but there must be a margin for operation, distribution, overhead costs and profit. An attempt will be made in the following analysis to determine what difference exists between the cost of central-station service and of private heating to cover those items.

It has already been shown that the average fuel cost of supplying radiation under the conditions named will be about 10c. to 15c. a sq.ft. for a season of eight months with coal at $1 a ton. The cost can be readily computed with coal at any other price. From a series of tests at the engineering experiment station of the University of Illinois,[1] the plant efficiencies for such equipment with the fuels named were as follows:

PLANT EFFICIENCIES FOR FIVE FUELS

Fuel	Average Efficiency per cent.
Illinois coal	48.86
Pocahontas coal	50.20
Anthracite coal	54.00
Gashouse coke	59.63
Solvay coke	61.73

The efficiencies given for Illinois coal are no doubt somewhat higher than will be maintained in practice by the average householder for an entire season. Based on the relative average heating values of the fuels named and with the efficiencies given, the prices at which the cost of heat would be equalized to the consumer are as follows:

DATA ON FOUR TYPES OF COALS

Fuel.	B.t.u. per Lb. as Fired, Average	Heat absorbed Total Value, Per Cent. Efficiency	Cost per Million B.t.u., Cents	Prices at Which Values Equalize
Illinois Coal	12,000	5,863	8.53	$1.00
Pocahontas coal	14,750	7,400	6.75	1.26
Anthracite	12,700	6,858	7.28	1.17
Coke	12,000	7,200	7.00	1.22

Thus it appears that with Illinois coal at $1 per ton we could afford to pay $1.26 for Pocahontas, $1.17 for anthracite and $1.22 for coke. The Illinois coal would therefore be in demand if it were not for other considerations than the cost of the heat. Some cities have smoke ordinances that make it nearly, if not quite, impossible for householders to burn Illinois coal. It also requires more labor to keep up the fires, remove ashes and clinkers and keep the heating surfaces free from soot. All things considered, Pocahontas coal, anthracite and coke are in demand at one and one-half to three times the cost of Illinois coal.

[1]Snodgrass, J. M. Fuel tests with house-heating boilers: Bull. 31, Univ. Illinois Eng. Exp. Sta. 1909, 108 pp.

These differences represent charges against dirt, smoke and excess labor. In other words, they are a contribution to cleanliness and convenience. Taking the Illinois coal at $1 a ton, with a heat value of 12,000 B.t.u. and 49 per cent. average efficiency, the cost of energizing a square foot of radiation for 180 twenty-four-hour days will be slightly higher than for the central station mentioned, at which the over-all efficiency of generation and distribution was taken at 50 per cent. The fuel costs for the heat are therefore about the same, whether furnished by the private plant or from a central station with the same coal at the same price.

However, there are these differences. The central station can work at a higher sustained efficiency, it can produce electric current as a byproduct with only a small loss of heat generated, and it eliminates all of the objectionable features of a private plant.

Value of Central-Station Service

The development of equipment and methods of operation in the boiler room of the modern power plant leave little to be accomplished there. Soft coal may be had under contract in Wisconsin at prices ranging from $2.50 to $3.50 a ton on track. It can be burned at an over-all efficiency of more than 70 per cent. and the product is heat with steam as the medium of transmission. Served in this manner through a distribution system, the heat has a value equivalent to the total cost of all items included in the operation of a private plant plus a considerable allowance for greater convenience and perfect cleanliness, and it should be so estimated in all computations on which costs and rates are based. Whether or not it is exhaust steam in whole or in part has no bearing on the case; any allowance in that direction should affect the price of current and not the cost or the value of the steam. The steam should be considered the prime requisite, with any output of incidentally derived current as the byproduct; it will then stand or fall on its own merits, which is the only substantial measurement of its value. The reasons on which this argument is based will be given later.

Price of Cleanliness

As regards the generation and transmission costs and margins, with coal at $3 a ton and an over-all efficiency in the plant of 70 per cent. the steam can be delivered at a fuel cost of approximately 30c. a sq.ft. of radiation served. This allows 20 per cent. for loss in transmission, a figure considerably higher than that found in practice, as evidenced by a report in Bulletin 40[2] of the Bureau of Mines, where this loss is given as 4 to 12 per cent. The same coal will cost the private user about $4 a ton delivered at his premises, and his fuel cost for the same amount of heat will therefore be not less than 40c. But he still has the smoke, dirt and labor inseparable from the use of soft coal in such equipment as he uses.

If the problem be viewed from another angle, the cost of evaporating a given quantity of water in the large public-service plant as against the small private plant may furnish a better basis for comparison. With Illinois coal at $1 a ton the fuel cost of evaporating 1000 lb. of water (generating 1000 lb. of steam) should not exceed 7c., and in a well-designed and carefully operated plant may be as low as 6c. The other costs will increase this figure to about 10c., and with coal at $3 a ton the total cost will be about 25c. The private consumer cannot evaporate the water any more cheaply, even with coal at the same price, and as he will have to pay more for his coal, the cost to him of evaporation will be more. Furthermore, when he requires only a little heat the efficiencies drop very low and the losses are correspondingly great.

[2]Randall, D. T., and Weeks, H. W. The smokeless combustion of coal in boiler furnaces, with a chapter on central heating plants. 1912, pp. 181-182.

In the estimate of the cost of supplying 1 sq.ft. of radiation for 180 days, a rate of emission of 2.5 B.t.u. per sq.ft. of surface and per degree difference of temperature per hour was used. This rate shows that 1,500,000 B.t.u. will be required to energize 1 sq.ft. of radiation for the 180-day period. In evaporating 1000 lb. of water there will be a heat transfer of approximately 1,000,000 B.t.u., at a cost of 25c. with coal at $3 per ton. From these figures it evidently will cost 38c. to 40c. to evaporate the water for each square foot of radiation supplied. To this figure must be added all investment, operation and other charges on the plant and distribution system. These can only be approximated in a general estimate, but they will probably equal the fuel cost, thus bringing the total up to 75c. or 80c. a square foot a season. The reader should bear in mind that in the computations made on the quantity of heat emitted the radiation was assumed to be active for the entire period. This will not necessarily hold in practice, and less heat will be required than the amount charged in this discussion. It makes little difference, however, as the lessening will be about the same amount whether the radiation system is heated privately or from a public-service main.

Rates for Steam

From schedules of rates in 28 cities of 25,000 to 40,000 inhabitants, covering many of the Middle States and ranging in latitude from Michigan and New York to Georgia and Alabama, the highest minimum is $1.50 per 1000 lb. of steam at Peoria, Ill., and the lowest for maximum consumption is $0.3105, at St. Joseph, Mo. The lowest minimum consumption rate is 54c. at Penn Yan and Geneva, N. Y., and the rate at these points for maximum consumption is 46.35c. The average minimum and maximum rates for the 28 cities, on quantities of 4000 lb. or less and 300,000 lb. or more per month, are 76.40c. and 45.33c. respectively.

Although a study of these rates shows lack of uniformity in the methods of their deduction, the averages given confirm in general the costs established herein for furnishing 1000 lb. of steam. In about half of the schedules mentioned there is a demand charge of $3 a month minimum on all buildings having a capacity of 25,000 cu.ft. of space or less, and 12c. per 1000 cu.ft. on all buildings having more than 25,000 cubic feet.

Thus far exhaust steam has not been considered, because there is no difference between it and live steam at the same pressure, and any exhaust steam that may become available for distribution costs just as much and it is worth just as much for heating as though a part of its original energy had not been converted into useful work. In a combined plant the product resulting from such conversion—usually electric current—should be considered the byproduct.

Where the heating load is large enough to entirely submerge the power load, there will be no peaks in the boiler room through variations in the latter. The power requirements may vary from zero to maximum and the firemen will not know it unless someone tells them or they consult the records. When the engines are exhausting their maximum into the heating system, the reducing valves will automatically cut the supply of live steam to the required amount; when the power load is a minimum, they will open and supply live steam to meet the requirements.

Fuel Conservation in Connecticut

IN order not to lose the impetus toward fuel economy gained under the stress of war conditions, manufacturers, power-plant owners, engineers and insurance interests in Connecticut are concerning themselves with a continuance of the conservation work begun last year in the power and boiler plants of the state, with every prospect that further gains will be secured during 1919. The fuel-conservation work in Connecticut typifies that done in many other parts of the United States under the guiding hand of the National Fuel Administration.

What was known in Connecticut as the Myers plan was elaborated and perfected in conjunction with other conservation committees and engineers and was finally adopted and promulgated by the United States Fuel Administration at Washington as the national plan for coal conservation in power plants, dating from May 1, 1918. The purpose of this plan was to reduce fuel waste in power-plant operation, not through expensive and extensive installation of more efficient apparatus, but by a more intelligent and careful use of the existing equipment. To accomplish this it was proposed to first ascertain by questionnaires how each plant complied with certain well-recognized standards in its operation and maintenance, and by a system of rating to force on the attention of the plant owner or responsible manager the wasteful conditions through which his plant failed of a higher score.

That there might be a strong incentive for improvement on the part of all, it was to be the announced intention that the relative rating of plants would influence the Fuel Administration's allotment of coal should a shortage occur. The plan further included a program of education through bulletins and other publications, lectures, meetings of plant owners, of engineers and firemen, to arouse an interest in and to maintain a constant effort for coal saving. The administration of this campaign in each state was to be in the hands of an engineer experienced in power-plant matters, and who, with his staff of workers, should be a part of the Conservation Division of the Fuel Administration. Mr. Corson, secretary of the Hartford Steam Boiler Inspection and Insurance Company, was appointed administrative engineer for Connecticut on June 17, 1918.

As Mr. Corson was a volunteer worker and could devote but a part of his time to this service, he had been authorized to secure as his assistant an engineer who would devote his entire time and effort to the work and would be compensated by a salary from the Fuel Administration. George H. Sharpe, a consulting engineer of the firm of Westcott & Mapes, Inc., of New Haven, influenced by a patriotic desire to be of service in the country's emergency, offered himself. Mr. Sharpe had all the qualifications required for the position and was accordingly nominated for appointment as Deputy Administrative Engineer for Connecticut. On July 22 he took up the duties of that position.

By the first of August the questionnaires filled out by the owners began flowing into the office, at first a few each day, but gradually increasing until the volunteer force of examiners was nearly swamped. Each questionnaire had to be examined and its answers marked and the plant rated and classified. For this work Prof. A. E. Knowlton, of Trinity College, Clarence C. Perry, of the Hartford Steam Boiler Inspection and Insurance Co. and William Ferguson and J. P. Calderwood, of the Travelers Indemnity Co., volunteered their services and gave constantly of their time and effort. When a questionnaire was valued, the owner of the plant was advised of the mark received by a form letter which showed him the effect of his rating of each item of his report. It thus became apparent to him in what features his plant was below standard. He was urged to give attention to them that he might secure a higher rating on the questionnaire that was to be returned by the inspector.

All together 1805 sets of questionnaires were mailed. Because of an imperfect mailing list, duplicates were sent to some plants and some questionnaires went to plants that used coal only for heating boilers of smaller size than those which it was the intention to rate. Instructions from Washington limited investigation to power plants and to heating plants of over 150 hp. capacity. Reports were received from 1467 plants, of which 918 were power plants or large-sized heating plants that had used during 1917 2,895,324 tons of coal. Of these, 562 plants, representing 2,104,759 tons of coal used in 1917, had been inspected and rerated when activities were halted by instructions received from

the United States Fuel Administration under date of Dec. 11, 1918. Power-plant owners received recommendations and suggestions in a spirit of cordial coöperation. Those who received high rating were evidently proud of it. Those who fell below a fair standard showed their eagerness to improve conditions. Many visited the administrative engineer's office personally to consult regarding plant features or operating practices that would prevent waste, and fuel-administration engineers made many special visits to plants by invitation of their owners to give advice on the prope combustion of fuel.

Substitution of Other Coals for Anthracite

In addition to the work of the administration and carrying on the national program for conservation in power plants, Mr. Corson's department endeavored to coöperate generally with the Connecticut Fuel Administration and to help by engineering advice, investigations, etc., in any matter that would conserve coal. In the early fall, especially, the scarcity of domestic sizes of anthracite coal made it essential that consumers who could do so should substitute bituminous or buckwheat coal. Mr. Sharpe and other engineers throughout the state spent much time with great success in teaching anthracite users how to use these other coals. In this way the department contributed greatly to an improvement of the anthracite situation in Connecticut.

The Light and Power Division of the United States Fuel Administration at Washington asked Mr. Corson's office to coöperate in efforts to substitute power from efficient public-service plants for that produced less economically. This could not be done without a clear knowledge of the available public-service power in the state and the definite location of its lines of distribution. Accordingly, Prof. A. E. Knowlton, who was also consulting engineer for the Connecticut Public Utilities Commission, undertook a general survey of the power and lighting plants of the state. His investigation was made in conjunction with E. Irvin Rudd, engineer of that commission, during the month of August and resulted in the accumulation of valuable data.

Inauguration of Contests for Coal Economy

In November, at the suggestion of Vice-President Samuel Ferguson of the Hartford Electric Light Co., the department invited a number of the larger public power plants of the state to join in a coal-economy contest. Three plants—the Hartford Electric Light Co., Hartford, The Connecticut Light and Power Co., Waterbury, and the Stamford Gas and Electric Co., Stamford—were interested and agreed to the competition. Each contestant paid an entrance fee of $5 per power-house employee. The basis of the contest was the percentage of improvement in coal burned per kilowatt-hour in a two weeks' run over a standard fixed for each plant from its experience for the previous fourteen months. The entrance fees were to be distributed as prizes to the power-house employees of the winning plants. The first contest began at 7 a.m., Nov. 11, and closed at 7 a.m., Nov. 24. It was won by the Hartford Electric Light Co. A second contest, based on the improvement in coal per kilowatt-hour over the average attained in the first contest, was arranged. This contest began on Dec. 2 and ended on Dec. 16. It resulted in the award of first prize to the Connecticut Light and Power Co., of Waterbury. A third contest had been arranged, but was called off when it was announced that the activities of the administrative engineer's department were to terminate. These contests evidenced clearly the wonderful results that may be secured under the stimulus of competition.

After the closing out of the engineering work in connection with the conservation division of the Connecticut Fuel Administration, Mr. Corson received from various power users and manufacturers in the state suggestions that the efforts on behalf of economical operation should be in some manner continued. The Manufacturers Association of Connecticut, Inc., wrote to the Hartford Steam Boiler Inspection and Insurance Co., expressing its interest in continued conservation work. Mr. Corson did not lose interest in the subject after relinquishing his duties as administrative engineer to the Fuel Administration, but expressed his desire that the economies gained might be continued and increased, pointing out that the industries of Connecticut as well as of the whole country will need every efficient practice in order to meet the broad world competition to be expected. The suggestion was made recently that the boiler-insurance companies establish a fuel-engineering inspection service, and in a bulletin dated Feb. 1, the Hartford Steam Boiler Inspection and Insurance Co. announced to its policy holders in Connecticut that it stands ready to assist them in this work. The company's engineering force is placed at the disposal of the policy holders in Connecticut as they may need it for the following purposes:

To advise and instruct concerning the use of draft gages, CO_2 apparatus, meters and other devices which may have been installed under the urgings of the Administrative Engineer; to instruct in proper methods of firing the different grades and qualities of fuel now being supplied; to investigate thoroughly plant conditions in order to point out where wastes are occurring; and to provide general supervision of plant operation. For advice and suggestions which are given entirely by correspondence no charge will be made; but when it is necessary for one of the company's engineers to visit a plant, a moderate charge will be made.

Connecticut power plants have been using about 3,000,000 tons of coal per year. The records of the distribution of coal show that 19/35 of the 1917 supply was sufficient for nine months' demand in the current coal year. On this basis the coal year ending Apr. 1, 1919, will in Connecticut require only 25/35 of the coal consumed in the state during the year ended Apr. 1, 1918. The department of the Administrative Engineer for Connecticut feels that its activities are entitled to much of the credit for this condition.

Hydro-Electric Power Bill

The hydro-electric power bill introduced by Senator Coalter early in the regular session of the West Virginia legislature never was reported from the Judiciary Committee of the Senate, to which it was referred after being favorably reported by the Finance Committee of that body. Just before final adjournment a Senate resolution was adopted asking Governor Cornwell to include the measure in his call for a special session which is to be held in March. It is doubtful, however, if the bill will be included in the call, since it is the desire of the governor to limit the legislature to the consideration of as few measures as possible.

The Swiss journal *Die Elektro-Industrie* gives particulars of a process for removing the temper from hardened steel. The piece to be softened is placed on a plate of iron at red heat and covered by a plate of cold iron. After the whole has cooled the piece of steel, whatever was its previous quality and degree of hardness, is detempered completely, and can easily be worked, without its quality having undergone any change by, for example, decarburization. The method is specially applicable to the unhardening of tools, more particularly punches and dies. Tests have given excellent results, and the method has the advantage that shaped pieces of steel do not show any shrinkage after treatment.

The Shawinigan Water and Power Co. has recently completed the longest transmission-line span in the world. The span is carried on steel towers 60 ft. square by 350 ft. high and crosses the St. Lawrence River about 20 miles from Three Rivers. A center span of 4801 ft. in length and two anchor spans, one 951 ft. and another 571 ft. in length, are used, making the total length of the crossing 6323 ft. Three galvanized-steel cables each 1⅜ in. in diameter make up the span. The total weight of each cable is approximately 30,000 pounds.

During the eight weeks ending Feb. 22, the United States Employment Service received 1,090,124 applications from men and women for jobs. Of this number 930,029 were referred to opportunities and 679,513 were reported placed in employment.

New Publications

INVENTOR'S MANUAL—HOW TO MAKE A PATENT PAY.—By George M. Hopkins. Second Edition, Revised and Enlarged. Published by The Norman W. Henley Publishing Co., New York City. Cloth; 133 pages; 5 x 7½ in. Price, $1.25.

The object of this book is to give the inventor and patentee some hints on patents generally, together with a few methods of bringing them to public notice. It is a book which, according to the author, contains a quarter of a century of the experience of a successful inventor, together with notes based on the experiences of many other inventors. The book not only gives instructions to inventors regarding the taking out of patent papers and disposing of them, but calls attention and gives caution as to pitfalls to those who are not acquainted as to the methods of procedure when obtaining a patent.

Personals

W. C. Kalb, formerly brush engineer with the National Carbon Co., of Cleveland, Ohio, is now with the Corliss Carbon Co., of Bradford, Penn.

J. E. Whittlesey, formerly connected with the Heine Boiler Co., is now sales manager of the Joseph L. Skeldon Engineering Co., of Cleveland, Ohio.

Howard C. Thayer has resigned as field mechanical engineer of the 100,000-kw. power plant of the United States Nitrate Plant No. 2, at Muscle Shoals, Ala., and is now the New York representative of the Baker-Dunbar-Allen Co.

C. W. Johnson, who was formerly chief inspector of works and later general superintendent of the Westinghouse Electric and Manufacturing Co., has been appointed assistant manager of works. Mr. Johnson has been with the company 12 years.

J. R. Lowe, who is well known in steam engineering circles in the South, has been appointed representative of the Midwest Engine Co., of Anderson, Ind., at its New Orleans (La.) office, and will handle the pump, oil engine and turbine business of the company in that section.

Hartley Le H. Smith, formerly chief of the testing bureau of the Brooklyn Rapid Transit system, is now in charge of the steam-engineering department of the New England Power Co., Worcester, Mass. Mr. Smith was connected with the Brooklyn Co. for more than 16 years.

Captain Edward E. Ashley, Jr., for many years consulting mechanical and electrical engineer for Starrett and Van Vleck, architects, of New York City, has resigned his position in the United States Air Service to accept an appointment as sales engineer of the Mercury Manufacturing Co., of Chicago.

Capt. George Sykes, R. A. F., who has been in this country nearly four years, attached to the British War Mission in a commercial capacity, sails for Europe in May. He has joined Messrs. Dutilh-Smith McMillan Co., an international house, as London manager of its engineering and railroad departments. His New York address is 50 Broad St., and his London office is Central Buildings, Totehill St., Westminster. He will be very glad to see his American friends at his London address.

Engineering Affairs

The American Association of Engineers, New York Chapter, will hold a meeting on the evening of Mar. 28, at the Hotel McAlpin. C. E. Drayer, the national secretary, will address the meeting.

Miscellaneous News

The Taylor Society will open a permanent office in the Engineering Societies' Building, 29 West 39th St., New York, on Apr. 1. The activities of the society will be conducted from this office by Dr. Harlow S. Person, who assumes the title of managing director. Dr. Person has been president of the Taylor Society for the past few years. He is director of the Amos Tuck School of Administration and Finance, Dartmouth College, Hanover, N. H., and professor of organization and management with that institution. He has severed his connection with the Tuck School and will devote his entire time to the affairs of the Taylor Society on assuming office.

The United States Civil Service Commission announces that thirty first-class boiler makers are urgently needed at the United States Navy Yard at Norfolk, Va. Pay ranges from $5.36 to $6.40 for eight hours. Permanent employment is assured. Thirty days' leave with full pay is granted at the expiration of the first year of service and for each month thereafter two and a half days' leave is allowed with full pay. When overtime is necessary, time and a half is allowed for all time in excess of eight hours. The Navy Department has authorized the commission to furnish transportation to qualified men from point of departure to Norfolk, if the men will agree to work for at least six months. United States citizens only will be considered. Full apprenticeship and good physical condition necessary. Application Form No. 1800 is required, which should be fully executed and filed with the Civil Service Commission at Washington, D. C. This form can be secured either from the commission's office or from one of its field representatives. They are located in all of the larger cities of the United States.

Business Items

The Dayton-Dick Co. of Quincy, Ill., has changed its name to the Dayton-Dowd Co. The change was made owing to changes in organization. Capital has been doubled and the business placed under the control of those immediately interested. Facilities are greatly extended.

Trade Catalogs

The Metal and Thermit Corp., New York City, has issued a very attractive large map calendar, which shows the new railroad time zones in the United States that went into effect Jan. 1 of this year.

Columbia Recording Thermometers. Schaeffer & Budenberg, Brooklyn, N. Y. Catalog No. 300. Pages 61, 7⅜ x 10¼ in.; attractively illustrated. A thorough and informative treatise on this type of instrument, which is for the accurate recording of all temperatures not exceeding 1060 deg. F.

The Jointless Fire Brick Co., Kingsbury and Clay Sts., Chicago, Ill., has just issued a 36-page instruction book on boiler-furnace linings, which contains useful and practical information on the installation of one-piece firebrick furnace linings. How to install and how to care for such linings are included in the contents.

The Jeffrey Type A Swing Hammer Shredder. The Jeffrey Manufacturing Co., Columbus, Ohio. Catalog No. 245. Pages 24, 6 x 9 in. In addition to a complete description, illustrated, of this type of shredder, this catalog shows typical arrangements of Jeffrey elevating and conveying equipments used in connection with same for handling the various materials.

Modern Methods of Ash Disposal is the title of a new catalog issued by the American Steam Conveyor Corp. This 160-page book is a treatise on the subject of ash handling. The first part is a comprehensive study of ash conveying equipment, and practically every type of conveyor is listed, the advantages and objections of each being enumerated. A large part of the book is devoted to a description of the company's ash conveyor and each of the patented steam fittings is described and illustrated. An interesting article shows the manner of application of the steam conveyor to boilers and stokers of various makes and a large number of diagrams clarify the discussion. Typical installations of steam conveyors are also described and illustrated. This catalog will not be given out indiscriminately, but copies will be given to engineers or plant owners supplying the following information: Present method of ash handling; number, type and horsepower of boilers; average steam pressure.

New Construction

PROPOSED WORK

Mass., Fall River—The city plans to build a new pumping station and dam. Estimated cost, $150,000.

Conn., Bridgeport—St. Michael's Polish congregation, 310 Sterling St., will install a steam heating plant in the school which it plans to build. Total estimated cost, $125,000.

R. I., Providence—The city will receive bids about May for the construction of a 2-story central heating plant. Estimated cost, $50,000. J. H. Gainer, Mayor.

N. Y., Brooklyn—The Cushman Baking Co., 44 Manhattan Ave., will install a steam heating plant in the 3-story, 60 x 100 ft. bakery which it plans to build on Nostrand Ave. and Malbone St. Total estimated cost, $125,000. Slee & Bryson, 154 Montague St., Arch.

N. Y., Brooklyn—Lehn & Fink, 129 William St., New York City, will install a steam heating plant in the 8-story, 40 x 100 ft. factory which it plans to build on Irving and Columbia St. Buchman & Kahn, 56 West 45th St., New York City, Arch.

N. Y. Huntington Park (Huntington P. O.)—A. Heckscher, 50 East 42nd St., New York City, will install a steam heating plant in the 1-story, 44 x 113 ft. museum which it plans to build here. Total estimated cost, $100,000. Maynicke & Franke, 25 East 26th St., New York City, Arch.

N. Y., Lockport—The Lockport Hydraulic Race Co. is receiving bids for the construction of a hydro-electric power plant and industrial building. L. H. Kunhardt, Ch. Engr.

N. Y., Long Island City—P. S. Karper & Bros., 68 West 34th St., New York City, will install a steam heating plant in the 6-story, 135 x 489 ft. factory which they plan to build on Jackson Ave. between Hulst and Harold Ave. Total estimated cost, $750,000. Ballinger & Perrot, 1328 Broadway, New York City, Arch.

N. Y., New York—The Stalwart Realty Co., c/o Ames & Co., 26 West 31st St., will install a steam heating plant in the 2-story, 100 x 171 ft. garage which it plans to build on Lenox Ave. between 110th and 111th Sts. Total estimated cost, $200,000. B. W. Levitan, 7 West 45th St., Arch. New West Side Garage Corp., lessee.

N. Y., Springwater—The Springwater Electric Light Co., Inc., has applied to the New York State Public Service Commission, Capitol, Albany, for permission to construct an electric plant here.

N. Y., Watertown—The New York Air Brake Co., Starbuck Ave., Northern New York Utilities Inc., Light & Power Bldg., J. B Wise, 401 Mill St., and associates, plan to incorporate the Beebee Island Corporation to develop power here. Plans include the construction of a power house, new concrete dam, flumes tailrace, the installation of 7500-hp. generating units, etc. Estimated cost, $500,000.

N. Y., Watertown—The Northern New York Utilities, Inc., Light & Power Bldg., will receive bids until Mar. 20 for the construction of a 1-story addition to the existing generating plant at Effley Falls, consisting of a 30 x 38 ft. power house, etc. J. B. Taylor, Pres. Noted Mar. 11.

N. Y., Watertown—The Watertown Bay Machine Co. has taken over the Eayer Electric Co.'s shop and will build additions and improvements to same for its own use. Estimated cost, $10,000. (The company will be interested to hear from power plant and transmission dealers.)

N. J., Newark—The American Oil & Supply Co., 52 Lafayette St., will install electric motors, pumping equipment, boiler apparatus, etc., in the factory which it plans to build at 238 Wilson Ave. Estimated cost of equipment, $25,000. P. B. Taylor, 31 Clinton St., Engr.

N. J., New Brunswick—The Eastern Potash Co., 120 Broadway, New York City, will install a steam heating plant in the potash plant which it will build. Total estimated cost, $2,000,000.

Penn., Bethlehem—The Travelers Tire Co., Travelers Bldg., Philadelphia, will install steam heating system, boiler and engine in the 2-story, 80 x 250 ft. factory which it plans to build near the Reading R.R. here. Total estimated cost, $250,000. J. O. Hunt, 114 North Montgomery St., Trenton, N. J., Arch.

Penn., Philadelphia—The Department of Public Works, City Hall, will install a heating system in the 1-story comfort building,

etc., which it plans to build at League Island Park. Total estimated cost, $250,000. R. E. White, Pennsylvania Bldg., Arch.

S. C., North Charleston—The General Asbestos & Rubber Co. plans to build a 600-kw. power plant. Estimated cost, $75,000. Lockwood Greene, Healey Bldg., Atlanta, Ga., Engr.

La., New Orleans—The city will install laundry unit, steam heating equipment, etc., in the 3-story hospital which it plans to build on Tulane and Carr Ave. Total estimated cost, $200,000. E. A. Christy, City Hall, Arch.

Tenn., Memphis—The Southern Motor Co., 631 Monroe Ave., is in the market for a direct connected lathe, 16 or 18 in. swing, with 6 to 10 ft. bed, with motor either single or three phase, 110 volt, a.c.

Ky., Henderson—The Henderson Cotton Mills having plans prepared for a 2500-kw. steam power plant. A steam heating plant will be installed in same. Estimated cost, $300,000. Lockwood Greene, Healey Bldg., Atlanta, Ga., Engr.

Ohio, Cincinnati—The Home Financing Co., c/o G. R. Bishop, 1209 Union Commercial Bank Bldg., will install a steam heating plant in the 8-story warehouse and terminal which it plans to build on Smith and Mill St. Total estimated cost, $3,000,000. A. M. Allen Co., 1900 Euclid Ave., Cleveland, Engr.

Ohio, Cleveland—The Board of Education, East 6th St. and Rockwell Ave., will install a steam heating plant in the 1-story addition to the school building which it plans to build on Warner Rd. Total estimated cost, $100,000. W. R. McCornack, East 6th St. and Rockwell Ave., Arch.

Ohio, Cleveland—The Cleveland Federal Reserve Bank, Williamson Bldg., will install a steam heating system in the 10 or 12-story, 150 x 200 ft. bank and office building which it plans to build on East 6th St. and Superior Ave. Estimated cost, $1,550,000.

Ohio, Cleveland—The Commercial Warehouse Co., c/o T. Knight, 250 The Arcade, plans to install a steam heating plant in the 10-story warehouse which it plans to build on Abbey Ave. Total estimated cost, $1,500,000. Fulton & Taylor, 631 Hippodrome Annex, Arch.

Ohio, Cleveland—Cowell & Hubbard, East 6th St. and Euclid Ave., will install a steam heating plant in the 2-story, 80 x 200 ft commercial building which it plans to build on Euclid Ave. and 13th St. Total estimated cost, $300,000. Walker & Weeks, 1900 Euclid Ave., Arch.

Ohio, Cleveland—Paul Bros. Co., Citizens Bldg., will install a steam heating plant in the 3-story, 99 x 133 ft. salesroom which it plans to build on East 18th St. near Euclid Ave. Total estimated cost, $115,000. W. S. Ferguson, 1900 Euclid Ave., Engr.

Ind., Vincennes—The Indiana Power & Water Co., Bloomfield, plans to improve its plant, to supply power and light to the Illinois oil fields to the west of Vincennes. Estimated cost, $150,000.

Mich., Detroit—The Morgan & Wright Tire Co., foot of Bellevue St., has awarded the contract for the construction of a 7-story, 140 x 215 ft. warehouse, to Bryant & Detweiler Co., 2336 Dime Bank Bldg. A steam heating plant and two electric boilers will be installed in same. Total estimated cost, $700,000.

Mich., Highland Park (Detroit P. O.)—The city will install two 150-hp. high pressure boilers, pumps and laundry equipment in the 4-story hospital which it plans to build. Total estimated cost, $300,000. Meyer J. Sturm, 114 South Michigan Ave., Chicago, Arch.

Mich., Marine City—The Banner Salt Co. plans to build a 1-story, 50 x 100 ft. power house. F. F. Van Tuyl, 1112 Union Trust Bldg., Detroit, Engr.

Mich., Ypsilanti—The City Council recommended that the city sink new well, install 12 new hydrants, and new pumping machinery with electric auxiliary, etc. Estimated cost, $32,000. W. R. Caldwell, City Engr.

Ill., Chicago—The Blackwood Hotel Co., Clarendon and Windsor Ave., will install a low pressure gravity heating system in the 9-story, 56 x 96 ft. hotel which it plans to build here. Total estimated cost, $250,000. J. A. Taggert, 108 South La Salle St., Arch.

Wis., Milwaukee—A. Kuenselmann, 450 Mitchell Ave., will install a refrigerating system in the 1-story, 140 x 160 ft. market building which he plans to build on Mitchell and 8th Ave. Total estimated cost, $175,000. W. G. Herbst, Arch.

Iowa, Marshalltown—The city plans an election Mar. 31 to vote on a $400,000 bond issue for the construction of an electrical plant large enough to furnish light and power for commercial purposes. O. A. Rosengren, City Clk.

Minn., Slayton—The Slayton Power Co. plans to enlarge its power plant here. F. H. Eddy, Supt.

Neb., Chadron—The Chadron Electric Co. plans to build an electric-light plant to supply the city with commercial current.

N. D., Fargo—The city plans election Apr. 1 to vote on $150,000 bonds for the construction of a light plant. F. L. Anders, City Engr.

N. D., Jamestown—The city plans election Apr. 7 to vote on bonds for the construction of light and power plant.

Okla., Stillwater—The city plans to install electric light and power plant machinery to increase its capacity. Estimated cost, $30,000.

Okla., Woodward—The city voted $30,000 bond issue for the installation of electric light and water-works plant machinery. Noted Feb. 11.

Ore., Eugene—The Eugene Fruit Growers' Association plans to build a cold storage and green apple packing plant, adjoining its cannery here.

Cal., San Diego—Olmsted & Gillelen, Engrs., 1112 Hollingsworth Bldg., Los Angeles, submitted report to city on sewage disposal plant. Plans include the installation of small pumping station to cost $32,500 and pumps at 32nd St. plant, $4000. Total estimated cost, $606,500. A. H. Wright, City Clk.

N. B., Lake Edward—The Department of Public Works, Ottawa, Ont., will soon award the contract for building a power house here. R. C. Wright, c/o Dept. of Pub. Wks., Ottawa, Arch.

Que., Three Rivers—The North Shore Power Co., Power Bldg., is receiving bids for the construction of an electric light station. Estimated cost, from $12,000 to $15,000. W. B. Baptist, Mgr.

Ont., Kingston—The Department of Public Works, Ottawa, will install a gravity steam heating system and two boilers, 60 in. diam. x 16 ft. long in the group of buildings which it plans to build at the Royal Military Hospital here. Total estimated cost, $400,000. R. C. Wright, c/o Dept. of Pub. Wks., Arch.

Ont., Port Arthur—The Ontario Hydro-Electric Comn., Toronto, plans to build a 1 story, 100 x 250 ft. power plant on the Nipigon River, Cameron Falls, near here. Estimated cost, $6,000,000.

Ont., Sydenham—The Department of Public Works, Ottawa, will receive bids until Mar. 21 for altering and building additions to military hospital here, same to be converted into power house, etc. Estimated cost, $75,000. R. C. Wright, c/o Dept. Pub. Wks., Arch.

Sask., Bounty—The village plans to build an electric light plant. G. A. Heron, Secy. Treas.

Sask., Broderick—The village plans to install an electric light plant. J. E. Alderson, Secy. Treas.

B. C., Squamish—The Department of Railways, Victoria, will soon award the contract for building dam, intake water supply system, hydro-electric power plants, transmission and lighting system, here. Estimated cost, $50,000. A. E. Procter, Victoria, Engr.

B. C., Vancouver—The Mainland Engineering Co., 422 Railway St., plans to construct a 54 x 125 ft. boiler and blacksmith shop, in connection with the foundry buildings which it plans to build. Total estimated cost, $70,000. Gardiner & Mercer, 827 Birks Bldg., Arch.

CONTRACTS AWARDED

Mass., Middletown—The Commissioners of Essex County have awarded the contract for the construction of a 1 and 2-story, 40 x 600 ft. hospital here, to C. E. Currier Co., 10 High St., Boston. Plans include the installation of power plant. Total estimated cost, $500,000.

Mich., Battle Creek—Nichols & Shepard has awarded the contract for the construction of a 2-story boiler plant, to Westinghouse, Church & Kerr, 37 Wall St., New York City. A steam heating system will be installed in same. Total estimated cost, $120,000.

Mich., Detroit—The Detroit Edison Co., David Whitney Bldg., has awarded the contract for building a 70 x 110 ft. addition to the central heating plant on Congress St., to A. A. Albrecht & Co., 1130 Penobscot Bldg.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.05@2.75	$2.80@3.20
Philadelphia, gross tons	4.15@4.90	5.00@5.45
New York, gross tons	4.50@5.25	5.35@5.80
Alongside Boston (water coal), gross tons	6.00@6.85	6.90@7.80

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5.95	$7.80	Pea	4.80	6.55
Egg	5.85	7.70	Buckwheat	3.40	5.15
Stove	6.10	7.95	Rice	2.90	4.65
Chestnut	6.20	8.05	Barley	2.40	4.15

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.50	$3.10 @ $3.50
Cambria County (good grades)	2.80 @ 3.10	2.95 @ 3.10
Clearfield County	2.65 @ 2.95	.....
Reynoldsville	2.65 @ 2.95	2.85 @ 3.00
Quemahoning	2.85 @ 3.10	2.95 @ 3.10
Somerset County (best grades)	2.80 @ 2.95	2.95 @ 3.10
Somerset County (poorer grades)	2.50 @ 2.75	2.75 @ 2.95
Western Maryland	2.50 @ 2.75	2.65 @ 2.85
Fairmont	2.00 @ 2.35	2.35 @ 2.50
Latrobe	2.25 @ 2.40	.....
Greensburg	2.35 @ 2.40	.....
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.40 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.30	Buckwheat	$3.40	$4.45
Egg	5.85	7.20	Rice	2.90	3.80
Stove	6.10	7.45	Boiler	2.70	3.70
Nut	6.20	7.55	Barley	2.40	3.30
Pea	4.80	6.05	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.75	$3.25
Mine-run	2.35@$2.50	3.00
Screenings	2.05	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	

Domestic quotations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	$4.50
Corona	3.75
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

	Mt. Olive and Staunton	Standard
Franklin County		
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....
Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2.25
Mine-run	2.20	2.20	1.60@1.70
Screenings	2.05	2.05	.95@1.10
3-in. lump	....	2.30	.....
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St. Louis is $1.10 other rates 92½c.